541200-M-2-TM

DATATAPE®

12-401D TAPE TRANSPORT

TECHNICAL MANUAL

BELL & HOWELL
DATATAPE DIVISION
300 SIERRA MADRE VILLA, PASADENA, CA 91109

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SECTION I

GENERAL DESCRIPTION

1-1. GENERAL.

1-2. The 12-401D Tape Transport is a rugged and reliable co-planar reel-to-reel transport. It incorporates dual capstans which provide excellent isolation from tape motion disturbances. One-half inch tape width is used in a 7-track record/reproduce system. One-inch tape width is used in a 14-track system. Backlighted pushbuttons control all operating modes which are electrically interlocked to prevent tape damage and to allow any sequence of operating mode selection. Optional remote control, bin loop adapter, voice logging, monitor meter, plug-in FM calibrator, rackmounting, and tape control servo accessories are available for use with the transport.

1-3. GENERAL PHYSICAL DESCRIPTION.

1-4. The 12-401D Tape Transport is supplied in either a portable or rackmount version. Both versions include either one or two amplifier cases, depending on whether the system is for 1/2-inch-wide or 1-inch-wide tape, respectively. The amplifier cases accommodate the record/reproduce electronics, the optional monitor meter, the plug-in FM calibrator, tape servo, and the voice logging unit. A power supply unit furnishes all operating voltage for the transport and signal electronics. The front of the transport is protected by a hinged dust cover. The system power switch and the transport controls are located on the front control panel. The power input and remote connectors are on the left side of the transport. An optional bin loop adapter is available as an accessory to the transport.

1-5. TYPICAL PERFORMANCE CHARACTERISTICS.

1-6. The typical performance characteristics for the 12-401D Tape Transport are listed in table 1-1.

ITEM	CHARACTERISTIC
Power	Tapped inputs for 200, 220, 240, 260 Vac or 115 Vac ±10%. Approximately 350 watts for 14-track systems. Frequency ranges: 47-63 Hz, 280-420 Hz (fan change required).
Overload Protection	Two 10-ampere slo-blow fuses on the primary power line.
Tape Tension	Tape tension on the head area is 6 oz ±1 for 1/2-inch-wide tape and 8 oz ±1 for 1-inch-wide tape.

Table 1-1. Typical Performance Characteristics (Sheet 1 of 3)

ITEM	CHARACTERISTIC
Fast Forward/Fast Reverse	600 feet per minute, nominal, capstan controlled.
Tape Speed Accuracy	Average tape speed accuracy is within ±0.15% of the selected tape speed for all speeds of 120 ips through 15/32 ips when in TACH mode; ±0.05% when in TAPE mode.
Fail-Safe	Transport stops by means of mechanical brakes in the event of a power failure or tape breakage.
End-of-Tape Sensor	Automatic transport stop at end-of-tape is provided. Tape can be run off the supply reel by commanding a forward mode.
Magnetic Heads:	The record and reproduce head stacks are precision mounted on a single plug-in assembly for easy replacement.
Head and Head Stack Configuration	Per IRIG 106-73.
Head Polarity	Per IRIG 106-73.
Head Azimuth	Record heads, factory set to better than ±1.0 minute of arc. (Reproduce heads adjustable.)
Head Life	In excess of 1000 hours.
Capstan Control	The dc capstan motor is controlled by a phase lock servo system which compares a tachometer or tape signal to a reference generator. Tape control servo mode establishes highly accurate tape speeds and low time base errors when reproducing tapes.
Operator Controls	Backlighted pushbutton switches are provided for STOP, RUN FORWARD, RUN REVERSE, RECORD, FAST FORWARD, and FAST REVERSE. A rotary switch is provided for speed and remote (R) control selection. Toggle switches are used for NORMAL, SHUTTLE, FORWARD SET, and REVERSE SET. Power ON is indicated by the illumination of the TAPE SPEED SELECTOR switch and is controlled by a rocker switch.

Table 1-1. Typical Performance Characteristics (Sheet 2 of 3)

ITEM	CHARACTERISTIC
	By placing the TAPE SPEED SELECTOR switch in the remote (R) position, the following functions can be selected remotely: Speed Selection — Run Forward Record — Run Reverse Fast Reverse — Stop Fast Forward — Shuttle
Overlap	Transport provides a near end-of-tape signal to transfer the recording operation to a standby transport when the radial tape stack on the supply reel diminishes to 1/8 to 1/16 inch. Transport is automatically stopped after transfer by the EOT sensors, providing overlap recording to preclude the loss of data.
Physical Size (Portable Configuration)	Height: 23-3/8 inches (59.37 cm) Width: 17 inches (43.18 cm) Depth: 13-5/8 inches (34.6 cm) Weight: Approximately 125 lbs (56.70 kg), excluding reels (1-inch tape width system).

Table 1-1. Typical Performance Characteristics (Sheet 3 of 3)

SECTION II

INSTALLATION

2-1. GENERAL.

2-2. The 12-401D Tape Transport is completely self-contained in its case assembly and is ready for operation after the system has been unpacked and installed. The record/reproduce electronics furnished with the transport are mounted in the amplifier case(s). Refer to Section II of the System Manual for the installation procedures of the 12-401D Tape Transport.

SECTION III

OPERATION

3-1. GENERAL.

3-2. The 12-401D Tape Transport is factory calibrated and ready for operation after the equipment is installed per instructions given in Section II of the System Manual. Personnel unfamiliar with this tape transport should read the operating instructions contained in the System Manual before attempting to place it in operation.

SECTION IV

THEORY OF OPERATION

4-1. GENERAL.

4-2. This section of the manual contains the circuit theory for the 12-401D Tape Transport. Block diagrams and simplified schematic diagrams are included to aid in understanding the circuit descriptions. References are also made to complete schematic diagrams contained in Section VII of this manual.

4-3. Descriptions of the circuits within the transport are divided into the following functional categories:

a. Capstan Servo System

b. Reel Servo Systems

c. Transport Control Logic

d. LED Footage Counter and Shuttle Control

e. Amplifier Mother Board

f. Reproduce Preamplifiers.

4-4. LOGIC ELEMENTS. Texas Instruments 74 series TTL integrated circuit digital logic is used extensively within the 12-401D Tape Transport. The logic elements used consist of NAND gates, NOR gates, inverters, and flip-flops. The elements are contained within plastic dual-in-line packages. Logic diagrams for each type of package are part of figures 7-1 and 7-2.

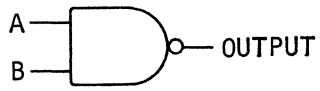
4-5. References are made in the circuit descriptions to a logical "0", or a logical "1". A logical "0" corresponds to zero volts and a logical "1" corresponds to approximately +3.3 volts. Boolean algebraic expressions are used, where appropriate, to indicate the function of logic paths. Arrows pointing up or down indicate a logical "1" or logical "0", respectively, when the conditions in the Boolean expression are satisfied.

4-6. Logic diagrams and truth tables for the most commonly used elements are shown in figure 4-1.

4-7. CAPSTAN SERVO SYSTEM.

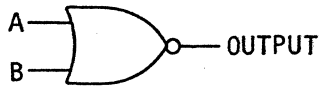
4-8. GENERAL. The function of the capstan servo system is to control the speed of the capstans. A feedback signal is derived from either a tachometer integral with the capstan motor or from a prerecorded reference signal. The feedback signal is compared with a stable crystal-controlled reference frequency. If the speed is incorrect, an error signal is derived to correct the speed of the capstan motor. A fast servo response time is employed to compensate for instantaneous speed variations due to low frequency flutter. This flutter compensation ensures minimum time base distortion.

NAND GATE



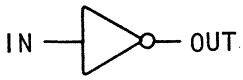
A	B	OUTPUT
0	0	1
0	1	1
1	0	1
1	1	0

NOR GATE



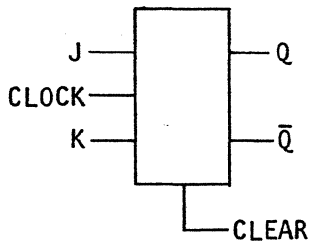
A	B	OUTPUT
0	0	1
0	1	0
1	0	0
1	1	0

INVERTER



IN	OUT
0	1
1	0

J-K FLIP-FLOP



t_n		t_n+1
J	K	Q
0	0	Q_n
0	1	0
1	0	1
1	1	$\bar{Q}_n$

t_n = Bit time before clock pulse

t_n+1 = Bit time after clock pulse

Low input to clear resets Q to "0", independent of clock

Figure 4-1. Commonly Used Logic Elements

4-9. A block diagram of the capstan servo system is shown in figure 4-2. This circuitry is located on the capstan and reel servo printed circuit board, which mates with receptacle A1J5. Figure 7-1 is the complete schematic diagram for this circuit board. Portions of the schematic corresponding to the blocks within figure 4-2 are highlighted by figures accompanying the circuit descriptions which follow.

4-10. TACH/TAPE SWITCH. The TACH/TAPE switch circuit, shown in figure 4-3, selects the source of the feedback signal which is subsequently compared to a precision reference frequency. The switch selects a feedback signal from either the capstan motor tachometer or the magnetic tape. The tape mode of servo control requires the optional 12-471 Tape Servo accessory in order to provide a tape feedback signal.

4-11. The tach or tape signal is selected by logic levels at connector A1J5-17. In the tach mode, a logical "1" will be present at NAND gate U13-13, which will enable the gate and apply the tachometer signal from connector A1J5-18 to NAND gate U13-9. NAND gate U13-6 will be held at a logical "1" by the action of inverter U9. Since NAND gate U13-10 is also a logical "1", the gate is enabled and the tachometer signal is fed to the coincident pulse eliminator circuit.

4-12. In the tape mode of servo control, a logical "0" is present at connector A1J5-17 and NAND gate U13-13, which holds the gate output U13-11 at a logical "1". At the same time, NAND gate U13-4 will be held at a logical "1", which enables the gate and allows the tape signal from connector A1J5-V to be coupled through both NAND gates and fed to the coincident pulse eliminator circuit.

4-13. REFERENCE AND TACH/TAPE PULSE GENERATORS. The pulse generators are connected between the coincident pulse eliminator and the comparator, as shown in the block diagram, figure 4-2. Their functions are to provide 160 ns pulses to drive the reference and feedback inputs of the comparator.

4-14. Figure 4-4 illustrates the operation of each pulse generator circuit. Three open collector inverters are connected as indicated. A zero at either of the inverter outputs at point C forces the other inverter output to a zero. When the input at point A goes low, the output at point C immediately goes to a logical "1" since the output of the other inverter cannot change instantaneously due to the charging time of capacitor C10. This charging time of C10 and C13, 100 pF each, provides 160 ns pulses at the reference and feedback pulse generator outputs, respectively.

4-15. COINCIDENT PULSE ELIMINATOR. This circuit is used to prevent the possibility of the reference and feedback pulses reaching both comparator inputs simultaneously. As shown on the block diagram, figure 4-2, this circuitry precedes the reference and tach/tape pulse generators described in paragraphs 4-13 and 4-14.

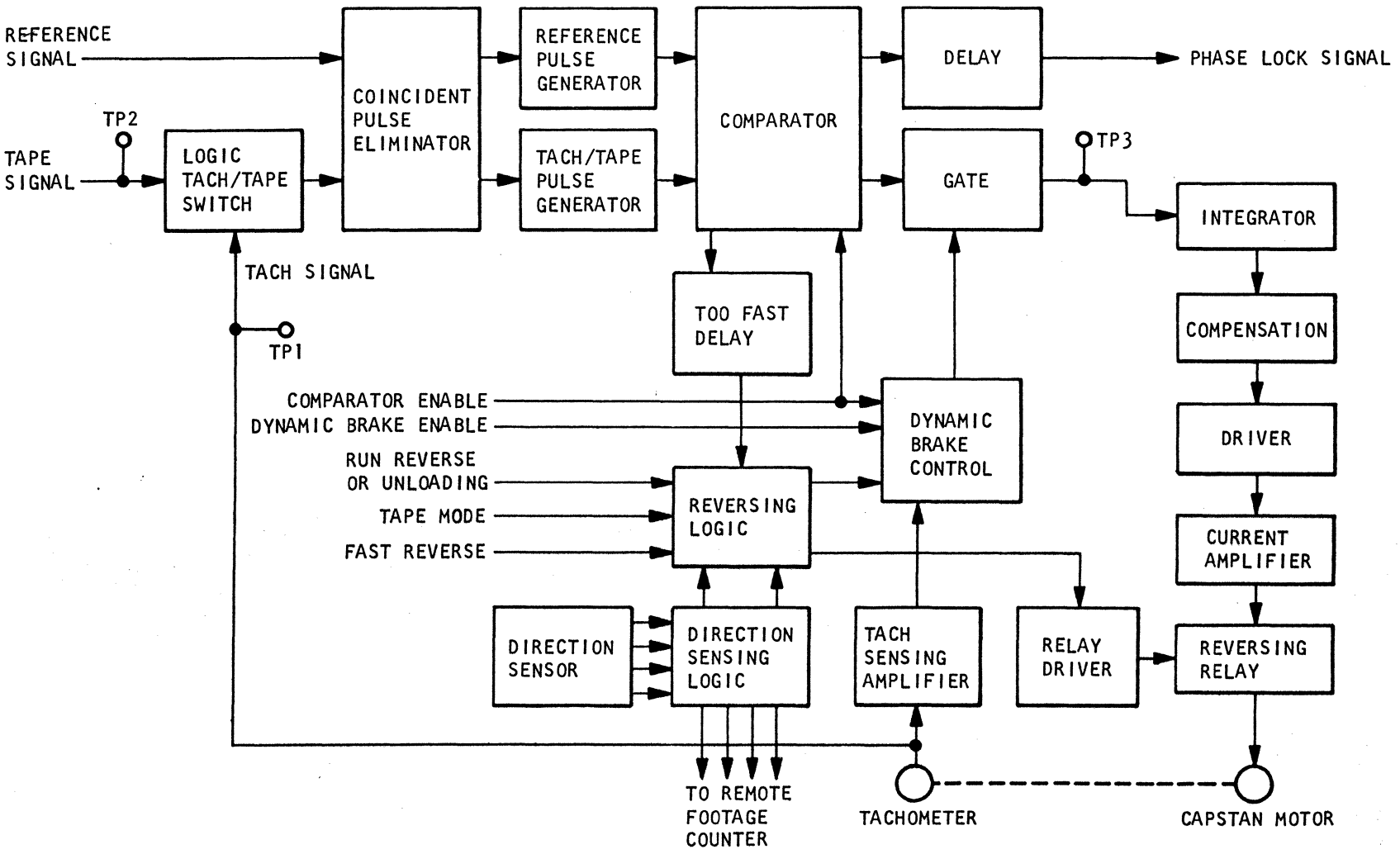


Figure 4-2. Block Diagram, 12-401D Capstan Servo System

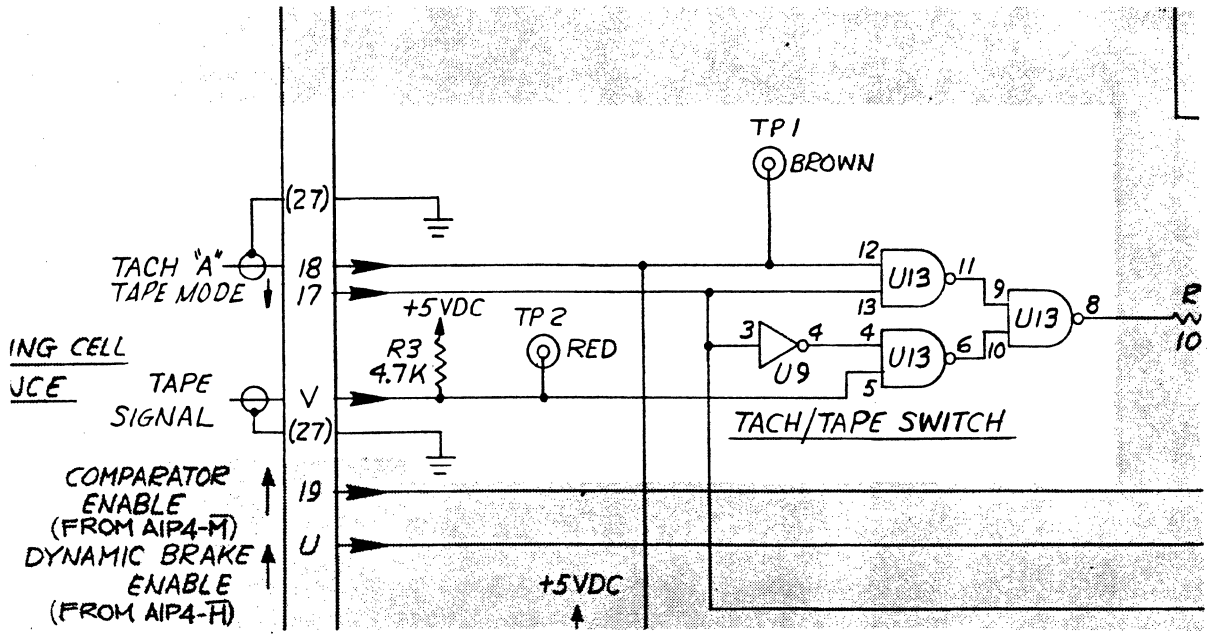


Figure 4-3. Schematic, Tape/Tach Switch

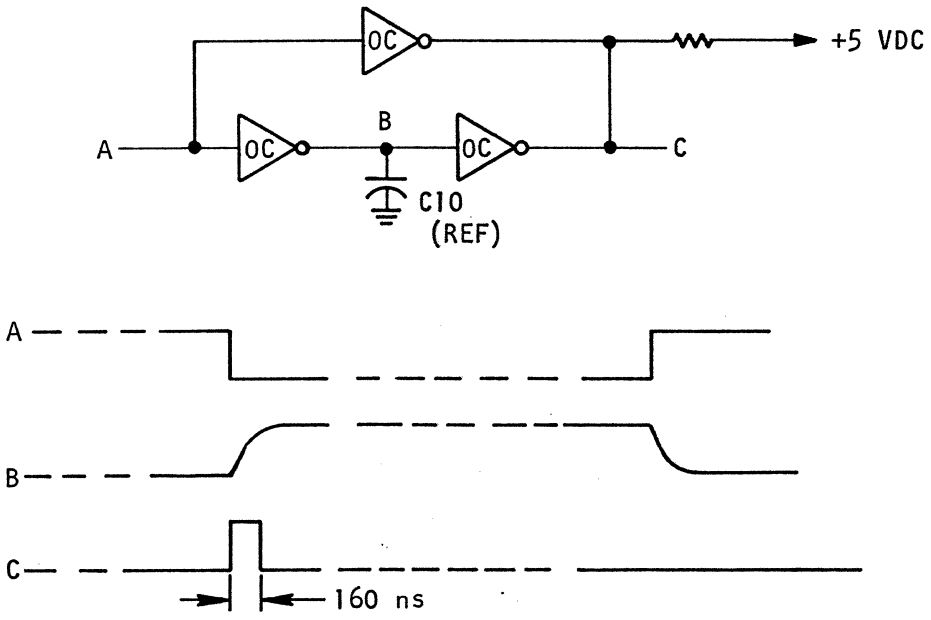


Figure 4-4. Pulse Generator

4-16. The coincident pulse eliminator circuit is highlighted in figure 4-5. It consists of two pulse generators as shown in figure 4-4 and two cross-coupled NAND gates which form a latch circuit. Figures 4-6, 4-7, and 4-8 show waveforms within the coincident pulse eliminator, together with the reference and tach/tape inputs to the phase comparator.

4-17. The trailing edge of the reference signal input generates an approximate 240 ns positive-going pulse within the pulse generator associated with capacitor C9. The trailing edge of this pulse, at U14-8, generates the 160 ns pulse within the reference pulse generator previously described in paragraph 4-14. In addition to the 240 ns pulse, the trailing edge of the reference input simultaneously generates a 600 ns positive-going pulse within the pulse generator associated with capacitor C11. This pulse, at U14-6, is applied to latching circuit input U16-12. The other latching circuit input at U16-9 is either the tach or tape feedback signal which comes from the TACH/TAPE switch described in paragraphs 4-10 through 4-12. The trailing edge of the latching circuit output at U16-8 generates the 160 ns tach/tape pulse within the pulse generator previously described in paragraph 4-14.

4-18. Figure 4-6 shows normal operation of the coincident pulse eliminator and reference and tach/tape pulse generators. In normal operation, the coincident pulse eliminator has no effect other than inverting the tach signal and delaying the reference by 240 ns. In coincident signal situations, the latch blocks the tach signal and the generation of the tach pulses for 600 ns. The tach signal is still present after this 600 ns time out because the 1/2 period of the tach signal is 2500 ns minimum. The reason for the 240 ns reference delay is in the event the tach pulse is still being generated when the trailing edge of the reference arrives. When the servo is phase locked and the tape is moving at the correct speed, the trailing edges of the reference and tach/tape inputs will occur approximately simultaneously. The tach/tape signal is inverted by the NAND gating used in the latch circuit and appears at U16-8. The 600 ns pulse at the other latch circuit input has no effect upon the signal. The trailing edge of the latch circuit output (U16-8) triggers the 160 ns tach/tape pulse generator. The reference and tach/tape pulses are combined within the comparator to form a clock signal. The pulses of the clock signal will be displaced from one another by approximately 180 degrees under the aforementioned conditions.

4-19. Figure 4-7 shows operation of the coincident pulse eliminator and reference and tach/tape pulse generators when the leading edge of the tach/tape input follows the trailing edge of the reference input within approximately 600 ns. During this time interval, the 600 ns pulse at U14-6 holds the latch circuit output (U16-8) at a logical "1". Thus, a clock pulse separation of 200 ns is maintained (360 ns between leading edges).

4-20. Figure 4-8 shows operation of the coincident pulse eliminator and reference and tach/tape pulse generators when the leading edge of the tach/tape input slightly precedes the trailing edge of the reference input. The 240 ns pulse generator ensures a pulse separation of at least 80 ns under these conditions. (At least 240 ns between leading edges.) This is the condition that makes it necessary to include the 240 ns delay in the reference.

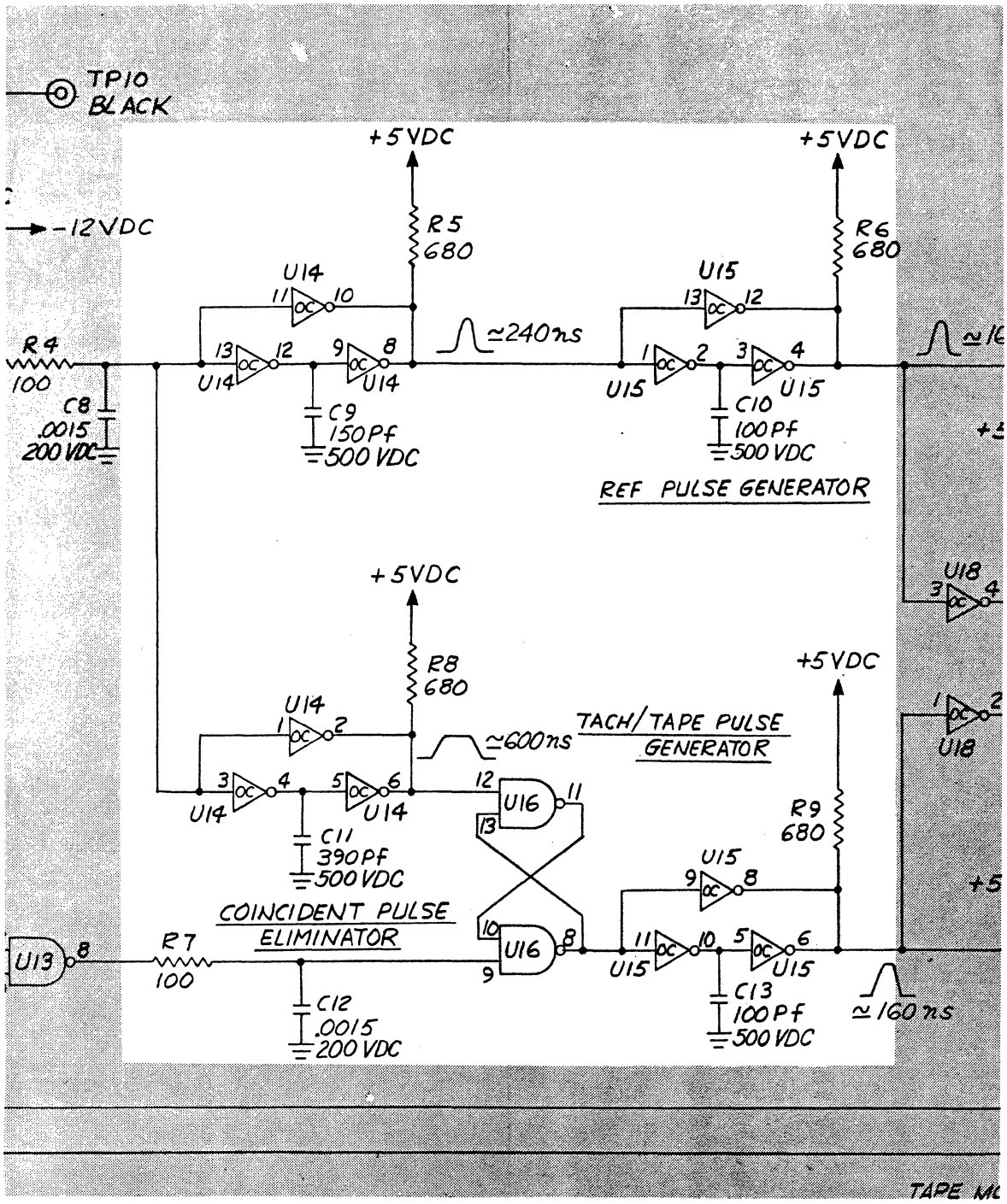


Figure 4-5. Coincident Pulse Eliminator, Reference Generator and Tach/Tape Generator

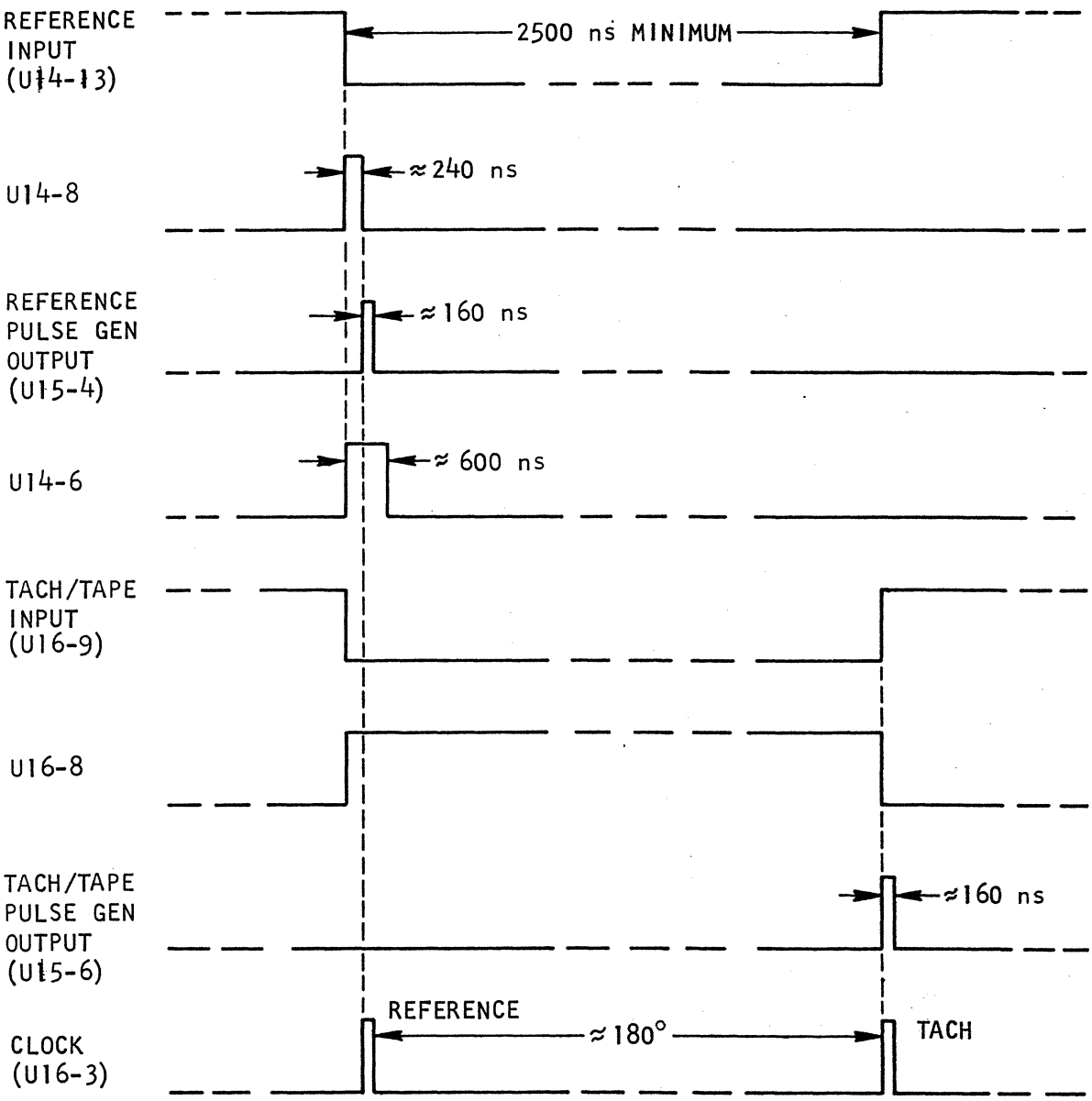


Figure 4-6. Reference and Tach/Tape Pulse Generation Non-Coincident Pulses

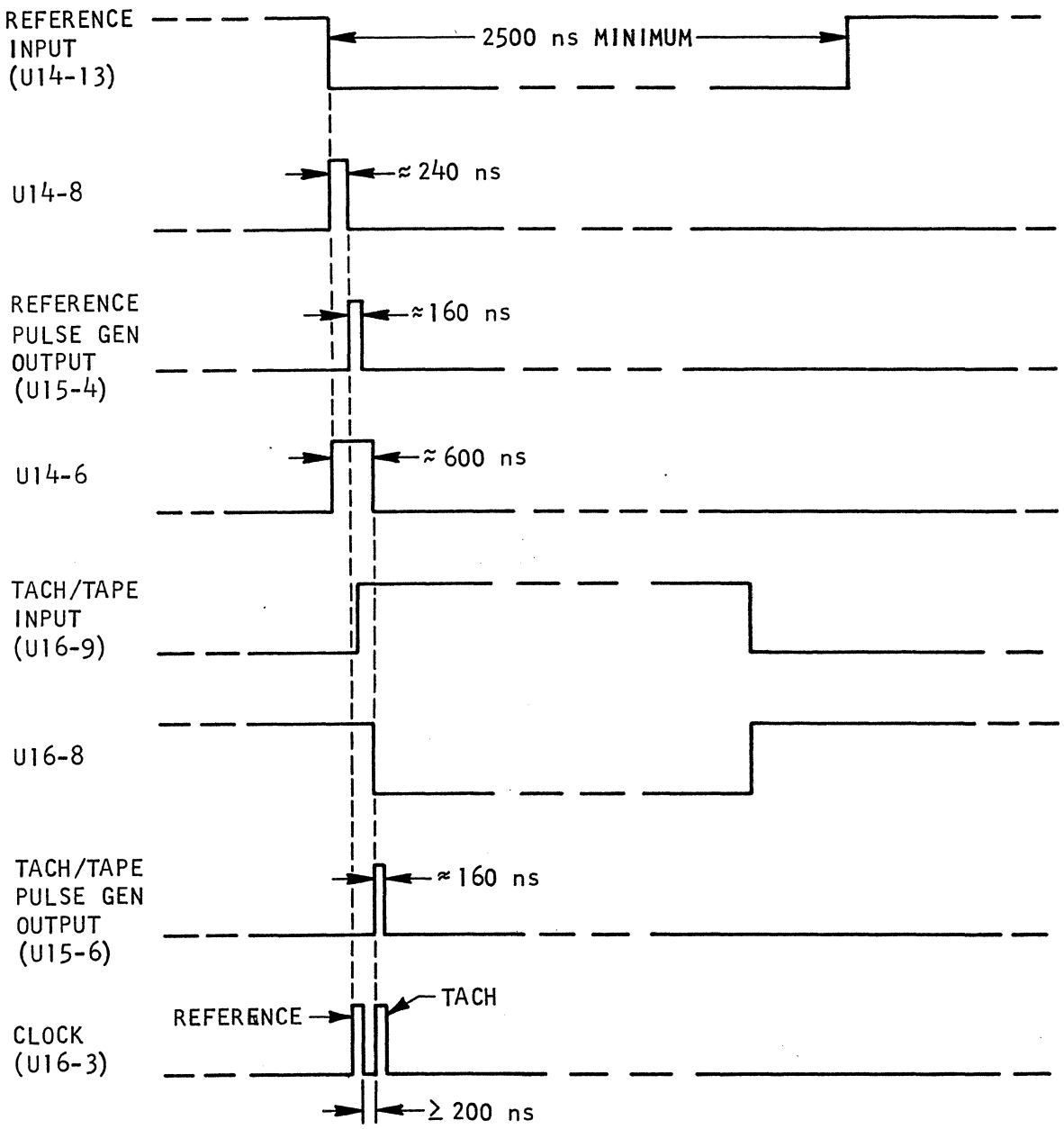


Figure 4-7. Reference and Tach/Tape Pulse Generation Coincident Pulses

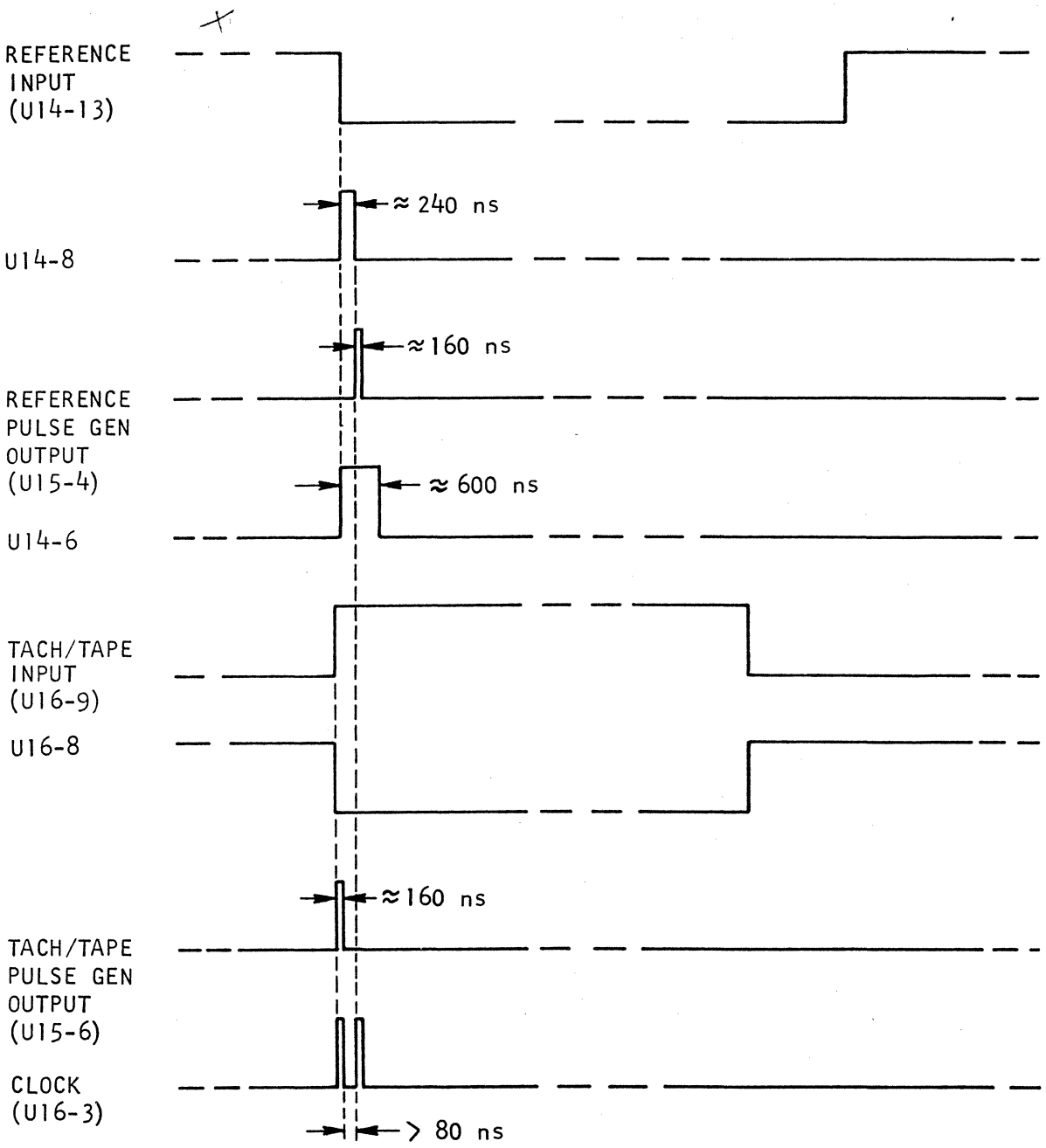


Figure 4-8. Reference and Tach/Tape Pulse Generation Coincident Pulses

4-21. COMPARATOR. The comparator compares the reference and tach/tape frequencies and provides output indicative of phase lock, too slow, or too fast conditions. The circuit is highlighted in figure 4-9. It consists of three flip-flops, two inverters, four NOR gates, and one NAND gate.

4-22. Figure 4-10 shows typical waveforms within the comparator for the three conditions. The inputs to the comparator are the 160 ns pulses derived in the reference and tach/tape pulse generators described previously. A clock signal formed by combining both inputs is applied to the three flip-flops at U20-5, U17-1, and U17-5. Both a clock signal and a set or reset input are required to change the state of a flip-flop. The comparator is enabled by a logical "1" applied to the flip-flops at U20-6, U17-2, and U17-6. The comparator enable line will be a logical "1" when the transport is in a run or fast mode of operation.

4-23. When the tape is moving too slow, there will be fewer tach or tape pulses than reference pulses coming into the comparator. This results in the upper and middle flip-flops on the schematic becoming set, while the lower flip-flop is toggled between set and reset by the reference and tach or tape pulses, respectively.

4-24. When the tach or tape pulses are occurring at the same rate as the reference frequency, the servo system is in a phase-locked condition. During phase lock, the upper flip-flop is set, the middle flip-flop toggles, and the lower flip-flop is reset.

4-25. When the tape is moving too fast, there will be more tach or tape pulses than reference pulses coming into the comparator. This results in the upper flip-flop toggling, while the middle and lower flip-flops are reset.

4-26. The set output of the upper flip-flop (U20-9) and the reset output of the lower flip-flop (U17-8) are applied to NAND gate U16-5 and U16-4, respectively. The waveform at the NAND gate output, U16-6, will be a square wave for too slow or too fast conditions, and a logical "0" when in phase lock. This signal is applied to the phase lock delay circuit. (See paragraph 4-28.)

4-27. A latch circuit, consisting of two cross-coupled NAND gates, is connected to the set output of the upper flip-flop (U20-9) and the reset output of the middle flip-flop (U17-13). The latch output, at U22-6, is a logical "1" for the too slow or phase locked conditions, and a logical "0" for the too fast conditions. This line is connected to the too fast delay circuit. (See paragraph 4-43.)

4-28. PHASE LOCK AND LOSS OF PHASE LOCK DELAY. The phase lock delay circuit is highlighted in figure 4-11. It consists of three inverters and two filter capacitors, C21 and C22. The delay circuit is driven from NAND gate U16-6 within the comparator. (The waveform at this point is shown in figure 4-10.) The output of the delay circuit at inverter U18-6 will be a logical "1" whenever the servo is phase locked. The capacitors slow the response of the circuit to keep the output of U18-6 low during too slow or too fast conditions, when a square wave is present at U16-6 and to delay the change in state of U18-6 when U16-6 changes state. The phase lock signal from the delay circuit is used to turn on the phase lock indicator light, and as a gating term for enabling tape servo control and the record mode.

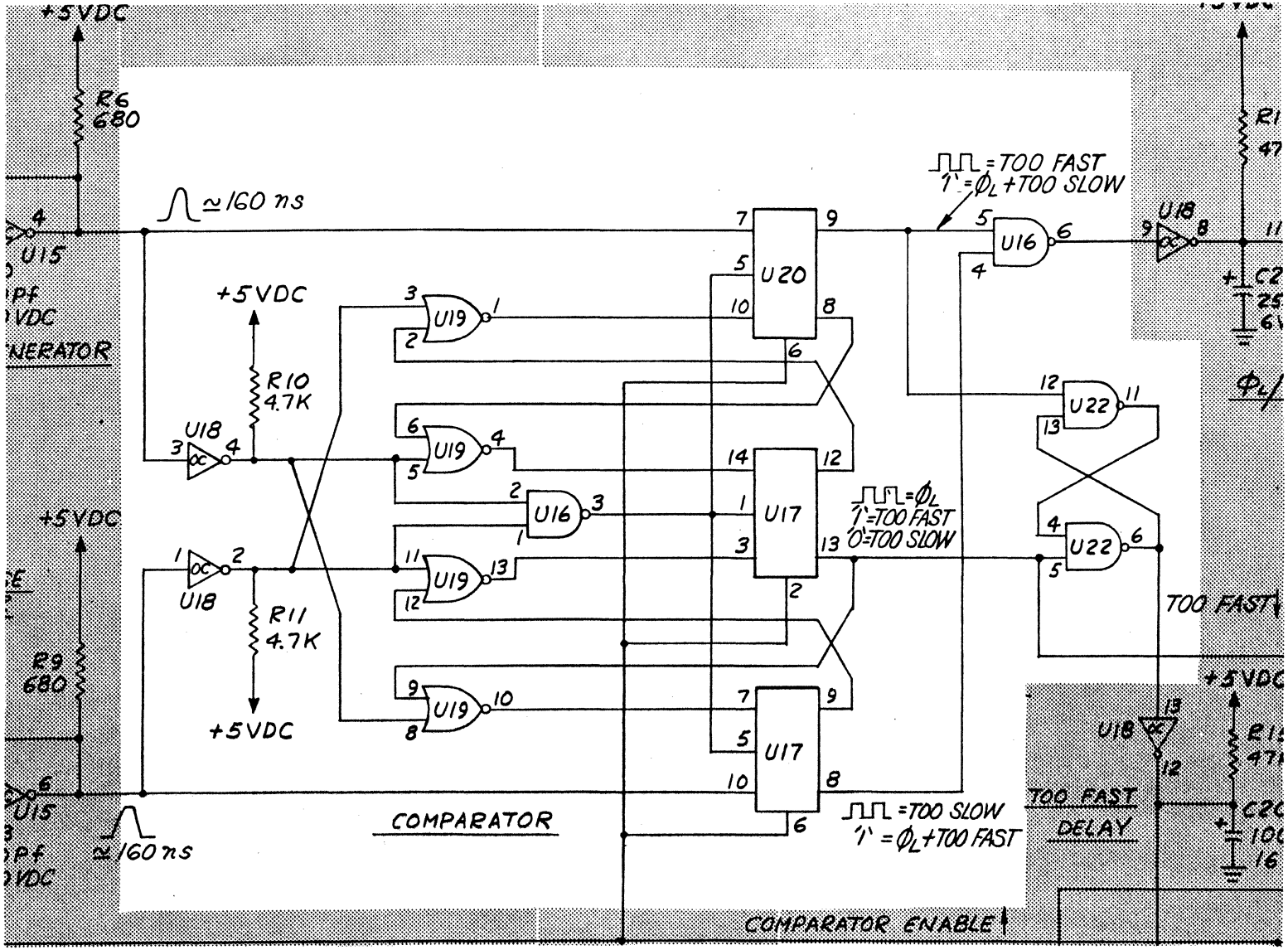


Figure 4-9. Capstan Servo Phase Comparator

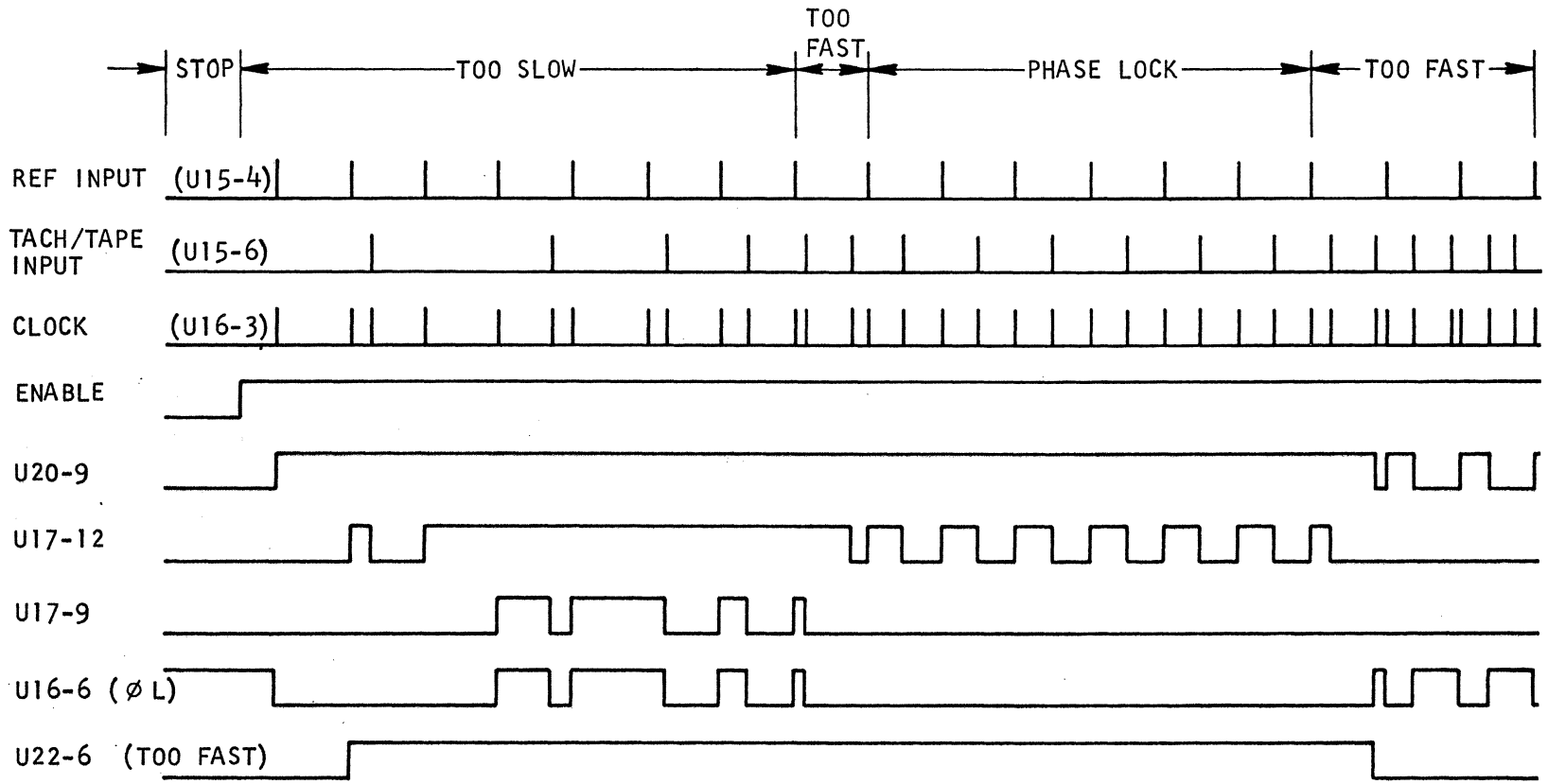


Figure 4-10. Typical Comparator Waveforms

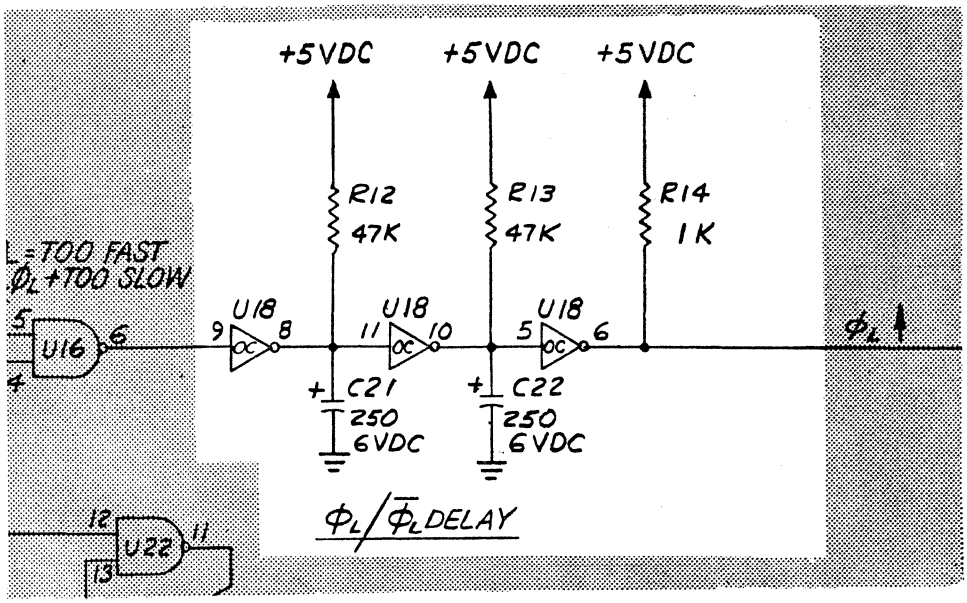


Figure 4-11. Schematic, Phase Lock Delay

4-29. COMPARATOR OUTPUT GATE. The signal at flip-flop U17-13 in the comparator circuit is coupled to one input of the output NAND gate at terminal U25-9. This signal is a square wave when the servo is phase locked, a logical "0" when too slow, and a logical "1" when too fast. The other NAND gate input (U25-10) is controlled by the dynamic brake control circuit described in a later paragraph. It is a logical "1" when dynamic braking is not being employed. The output of the gate (U25-8) when not braking, therefore, is a logical "1" when the tape is moving too slow, a square wave when phase locked, and a logical "0" when too fast. The gate output is connected to the input of the integrator, which may be monitored at TP3.

4-30. INTEGRATOR. The function of the integrator is to integrate the square wave received from the comparator gate during phase lock, converting it to a dc level which is amplified in succeeding stages and used to power the dc capstan motor. Any instantaneous speed variations alter the duty cycle of the comparator output square wave. The corresponding change in the integrator output voltage corrects the speed of the motor and reduces low frequency to a minimum.

4-31. Figure 4-12 highlights the integrator and succeeding stages. The integrator is basically an active second order low-pass filter with a 500 Hz cutoff frequency. The active element is an operational amplifier, U23, connected in a noninverting unity gain configuration. Filter networks made up of resistors R31 and R32 and capacitors C23 and C24 are used with the operational amplifier. Inductor L1 and capacitor C54 are series resonant at approximately 1.56 kHz to minimize ripple at the integrator output when the transport is operating at 15/16 ips. Diode CR2 protects the comparator output gate by clamping its output at U25-8 to +5 volts.

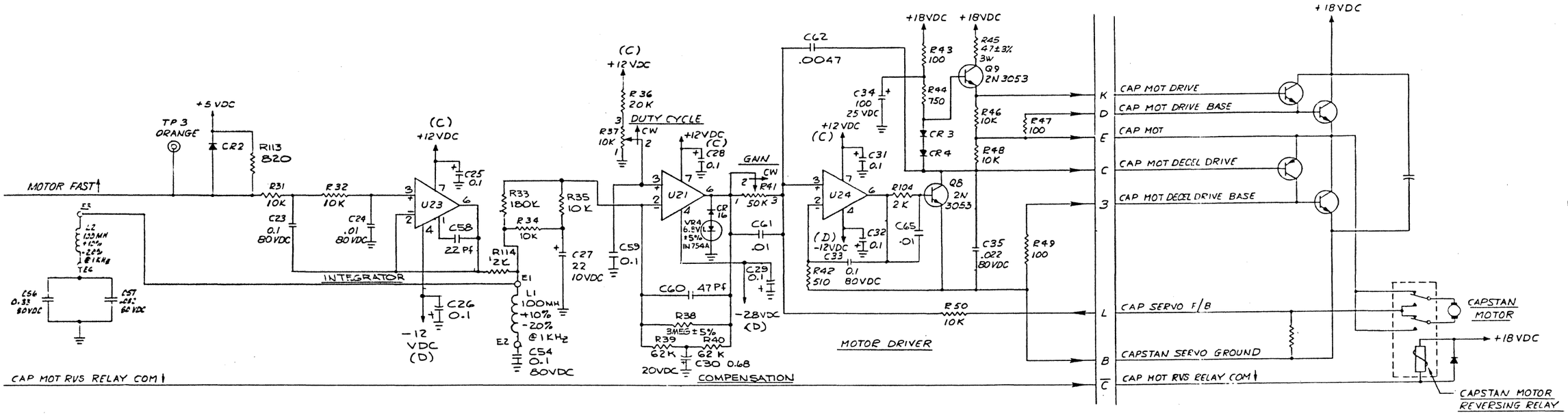


Figure 4-12. Schematic, Capstan Servo Integrator and Succeeding Stages

4-32. COMPENSATION. This circuit, which follows the integrator, has a response which compensates for the inertia characteristics of the capstan motor. The circuitry consists of an operational amplifier, U21, together with two RC networks. The first RC network consists of resistors R33, R34, and R35, together with capacitor C27. The second RC network forms a negative feedback loop around the operational amplifier and consists of resistors R38, R39, R40, and capacitor C30. The dc error signal derived in the integrator will be inverted by the compensation amplifier, U21. Diodes CR16 and VR4 limit the output to -7.5 volts. A variable resistance at the amplifier output, R41, provides control of the servo gain. A range of dc offset voltage from 0 to +4 volts is provided by potentiometer R37, which is connected to the noninverting input of the amplifier. This control is adjusted to produce an approximate 50 percent duty cycle square wave at TP3 when the servo is phase locked at all speeds.

4-33. DRIVER. The driver amplifies the compensated error signal from the preceding stage to a level sufficient to drive the capstan motor power amplifier. It consists of operational amplifier U24 and transistors Q8 and Q9. The input signal comes from gain control R41 and is applied to the noninverting input of the amplifier. Also connected to this input is resistor R50, which supplies a feedback voltage from a 0.5 ohm resistor in series with the capstan motor. The feedback voltage becomes more positive with increasing motor current and serves to maintain a constant motor current. The output of operational amplifier U24 is connected through protective resistor R104 to the base of transistor Q8. The collector of Q8 is connected through circuit board receptacle terminal C to the base of an MJE 2955 PNP transistor (A1A2Q3) located on the transport plate. The collector of Q8 is also connected through diodes CR3 and CR4 to the base of transistor Q9. The emitter of transistor Q9 is connected through circuit board receptacle terminal K to the base of an MJE 3055 NPN transistor (A1A2Q1) located on the transport plate. The manner in which the driver controls the motor speed is discussed together with the power amplifier in paragraph 4-35.

4-34. POWER AMPLIFIER. The power amplifier is shown in detail in figure 7-3, the transport assembly schematic diagram. It is also shown in simplified form in figures 4-12 and 7-1. The power amplifier utilizes four power transistors to control the capstan motor voltage and current. The transistors are mounted on the transport plate, which serves as a heat sink.

4-35. The base of transistor Q1 is connected through connector A1J5-K to the emitter of transistor Q9 in the driver circuit. Transistor Q1 serves as a current amplifier to drive transistor Q2, which is in series with the capstan motor. The motor is powered from the +18 volt power supply. Current flows from the power supply, and through series transistor Q2, contacts of reversing relay K1, the capstan motor, and a 0.5 ohm resistor, R1, to the servo ground at A1J5-B. Transistor Q2 determines the voltage delivered to the motor. The reversing relay contacts determine the direction of current flow through the motor and, hence, its direction. Resistor R1 provides a feedback voltage proportional to the motor current. This voltage is fed back to the driver circuit as described in paragraph 4-33.

4-36. The base of transistor Q3 is connected through connector A1J5-C to the collector of transistor Q8 in the driver circuit. Transistor Q3 serves as a current amplifier to drive transistor Q4, which is in parallel with the capstan motor. Transistor Q4 is used to decrease capstan deceleration time by loading down the generator effect of the unpowered, but still moving, motor.

4-37. CAPSTAN DRIVER AND POWER AMPLIFIER OPERATION.

a. Tape Servo At Phase Lock. At phase lock, the voltage at the output of the motor driver amplifier (U24-10) is slightly positive. This forward biases the emitter-to-base junction of transistor Q8 and causes approximately 1.3 mA of current to flow through diodes CR3 and CR4 and resistors R43 and R44. The voltage drop across the two resistors causes the base voltage of transistor Q9 to be approximately +7 volts. Transistor Q9 thereby conducts current, as do transistors Q1 and Q2 on the transport mounting plate. Transistors Q1, Q2, and Q9 are emitter-followers which provide the required current gain. The voltage applied to the motor is equal to the base voltage of Q9 less the base-emitter drop of Q1, Q2, and Q9. Since transistor Q2 is in series with the capstan motor and the +18 volt supply, the motor is energized. The motor voltage at phase lock ranges from approximately +4 volts at 15/16 ips to +7 volts at 60 ips. The base voltage of transistor Q3 on the transport mounting plate is the same as the emitter voltage. Therefore, both transistors Q3 and Q4 are cut off.

b. Tape Speed Too Slow. When the tape moves too slowly, the comparator output (TP3) goes to a logical "1", which results in a negative voltage at the output of the motor driver amplifier U24-10. Transistor Q8 is therefore cut off which makes the base voltage of transistor Q9 approximately +9 volts. Transistors Q9, Q1, and Q2 conduct and the motor is supplied with an increased voltage to increase its speed until phase lock is reached. Transistors Q3 and Q4 remain cut off.

c. Tape Speed Too Fast. When the tape tends to move too fast in the run mode, the capstan motor must be decelerated. Two deceleration techniques are used. They are determined by the too fast delay circuit discussed in a later paragraph. When in the tape mode, the comparator output (TP3) is a logical "0" for any too fast condition. This causes the output of the motor driver amplifier (U24-10) to go positive enough to saturate transistor Q8. The collector voltage of transistor Q8 therefore goes to ground. This reduces the base voltage of transistor Q9 to nearly ground potential, resulting in transistors Q1 and Q2 on the transport mounting plate shutting down and removing all capstan motor voltage. At the same time, the ground potential at the base of transistor Q3 causes transistors Q3 and Q4 to saturate. Transistor Q4 is effectively a short across the capstan motor, which serves to load down the generator effect of the unpowered but still moving motor, thus shortening the deceleration time. When in the tach mode, the driver and power amplifier operate for the first 3/4 second of deceleration as described for the tape mode. However, if after 3/4 second, the tape speed is still too fast, the too fast delay circuit acts through the reversing logic and dynamic brake control circuits (discussed in a later paragraph) to cause the comparator output to change from a logical "0" to a logical "1". At the same time, the reversing relay changes state. The logical "1" at the comparator output results in a negative voltage at the output of the motor driver amplifier. Transistor Q8 is therefore cut off, which causes transistors Q9, Q1, and Q2 to conduct, thus the capstan motor is supplied with full voltage. Since the reversing relay changes state at the end of the 3/4 second too fast delay, reverse torque is exerted by the capstan motor to ensure maximum deceleration until phase lock is again achieved.

4-38. DIRECTION SENSOR. A direction sensor is used to control the reversing and dynamic braking logic within the transport and to drive the remote footage counter. It consists of assembly A1A2A6, and is mounted at the rear of the capstan near the supply reel. This capstan is belt driven from the other capstan which is integral with the motor.

4-39. A complete schematic diagram of the direction sensor is part of figure 7-3. The sensor is shown in simplified form in figure 4-13, together with its connections to the servo circuit board. Affixed to the rear of the supply capstan shaft is a rotor to which are cemented three strips of reflective material spaced 120 degrees apart. A light source (DS1) is positioned central to the revolving rotor such that each reflective strip is illuminated. Four phototransistors, Q1(A), Q2(B), Q3(C), and Q4(D), are positioned equidistant from one another near the rotor such that they are sequentially struck with the reflected beam of light from each strip. The three rotating beams of light strike the four fixed phototransistors in a sequence determined by the direction of capstan and rotor rotation. This sequence is illustrated in the upper left-hand corner of figure 4-13. For example, in the forward direction, first transistor "A" alone is illuminated; then, both transistors "A" and "B" are illuminated; next, only "B" is illuminated, then "B" and "C", etc. The sequence is reversed when the tape is moving in the reverse direction.

4-40. As each phototransistor is illuminated, it is turned on and the emitter voltage becomes positive. Connections are made to the circuit card containing the phototransistors via printed circuit card receptacle A1J10. The emitters of the four transistors are connected by the transport cabling from A1J10 to the servo board receptacle A1J5.

4-41. DIRECTION SENSING LOGIC. The direction sensing logic circuit determines tape direction by comparing the four direction sensor output waveforms. The circuit is a part of the capstan and reel servos circuit board shown schematically in figure 7-1. The applicable portion of the schematic is highlighted in figure 4-13. Figures 4-14 and 4-15 are timing diagrams which illustrate the operation of the direction sensing logic during forward and reverse tape motion, respectively. Since the rotor utilizes three mirrors, it is possible for more than one transistor to be turned on simultaneously. The waveforms at U10-12 and U10-6 represent the times during the rotation of the rotor when "A" only and "C" only are turned on. The direction is then determined by using "A" only and "C" only as references, should A and B, and C and D occur after the reference then the direction is forward. Conversely, should A and D, and C and B occur after the reference then the direction is reverse. The phototransistor turn-on sequence is shown in the upper portion of the timing diagrams.

4-42. The two direction sensing logic outputs are derived from a latching circuit formed by two cross-coupled NAND gates. When the tape is moving in a forward direction, NAND gate terminal U11-1 is a logical "1" and terminal U11-3 is a logical "0". The converse is true in the reverse direction, with terminal U11-1 a logical "0" and U11-3 a logical "1".

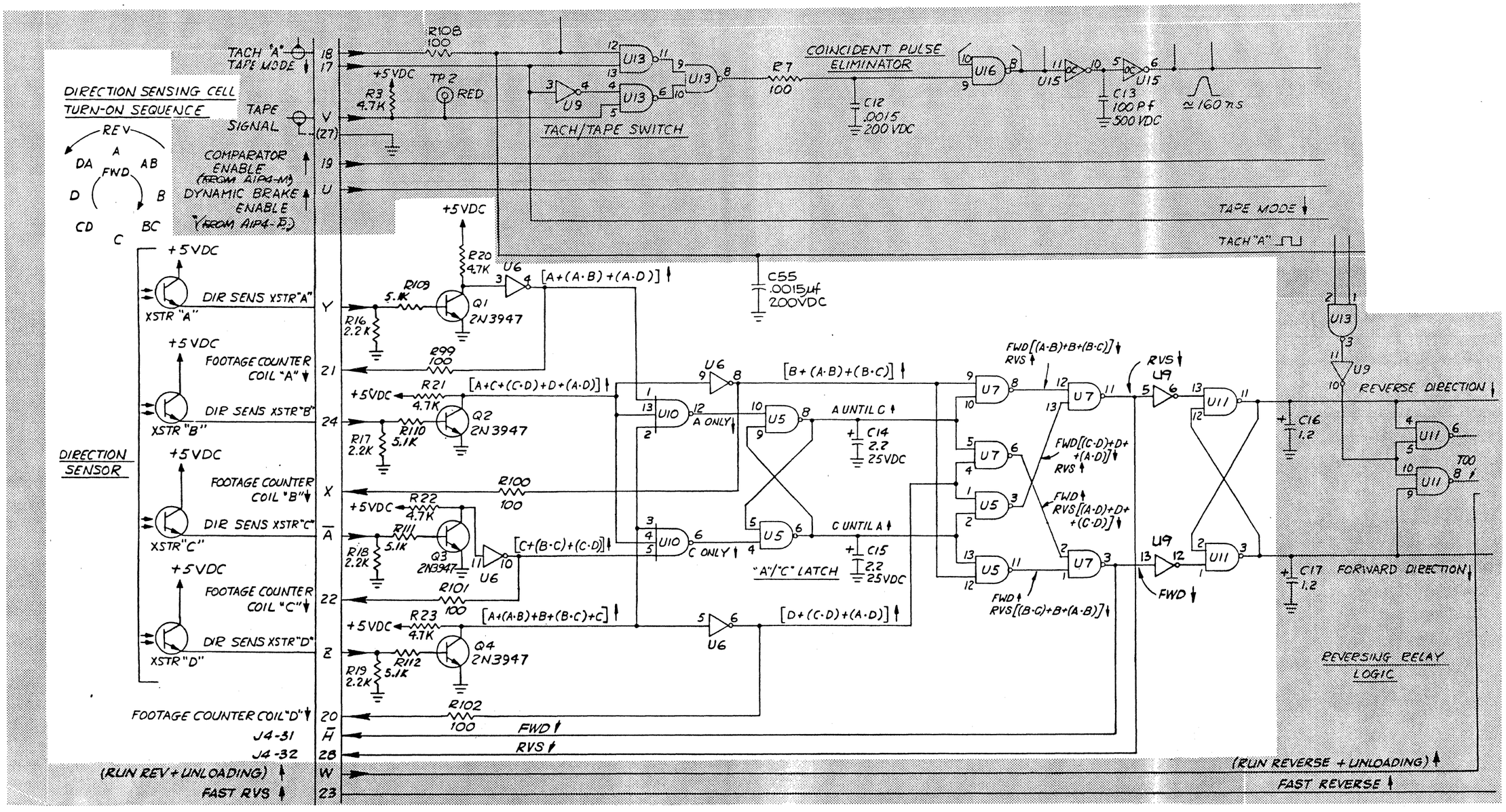


Figure 4-13. Direction Sensor and Direction Sensing Logic

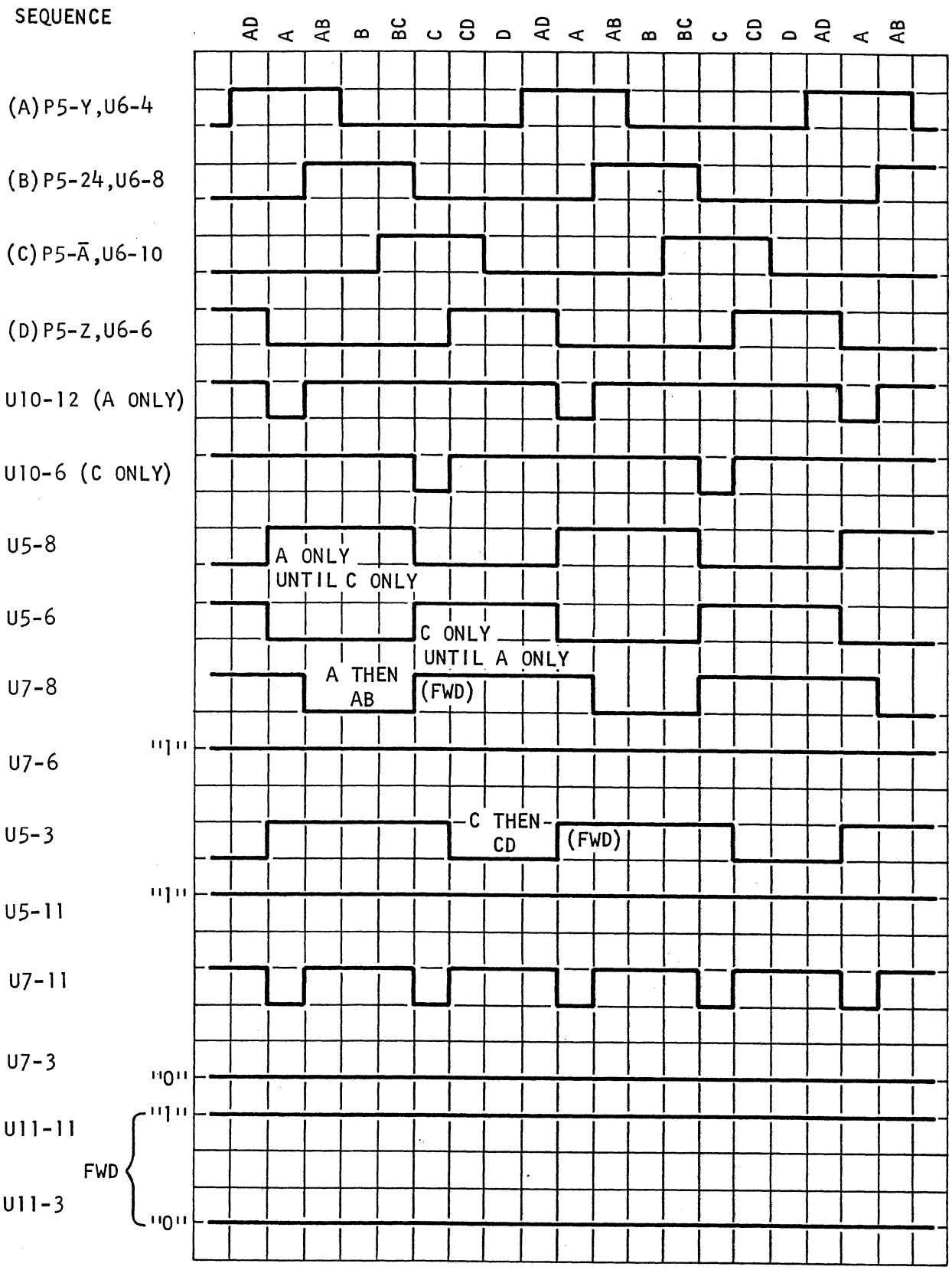


Figure 4-14. Timing Diagram, Direction Sensing Logic, Forward Direction

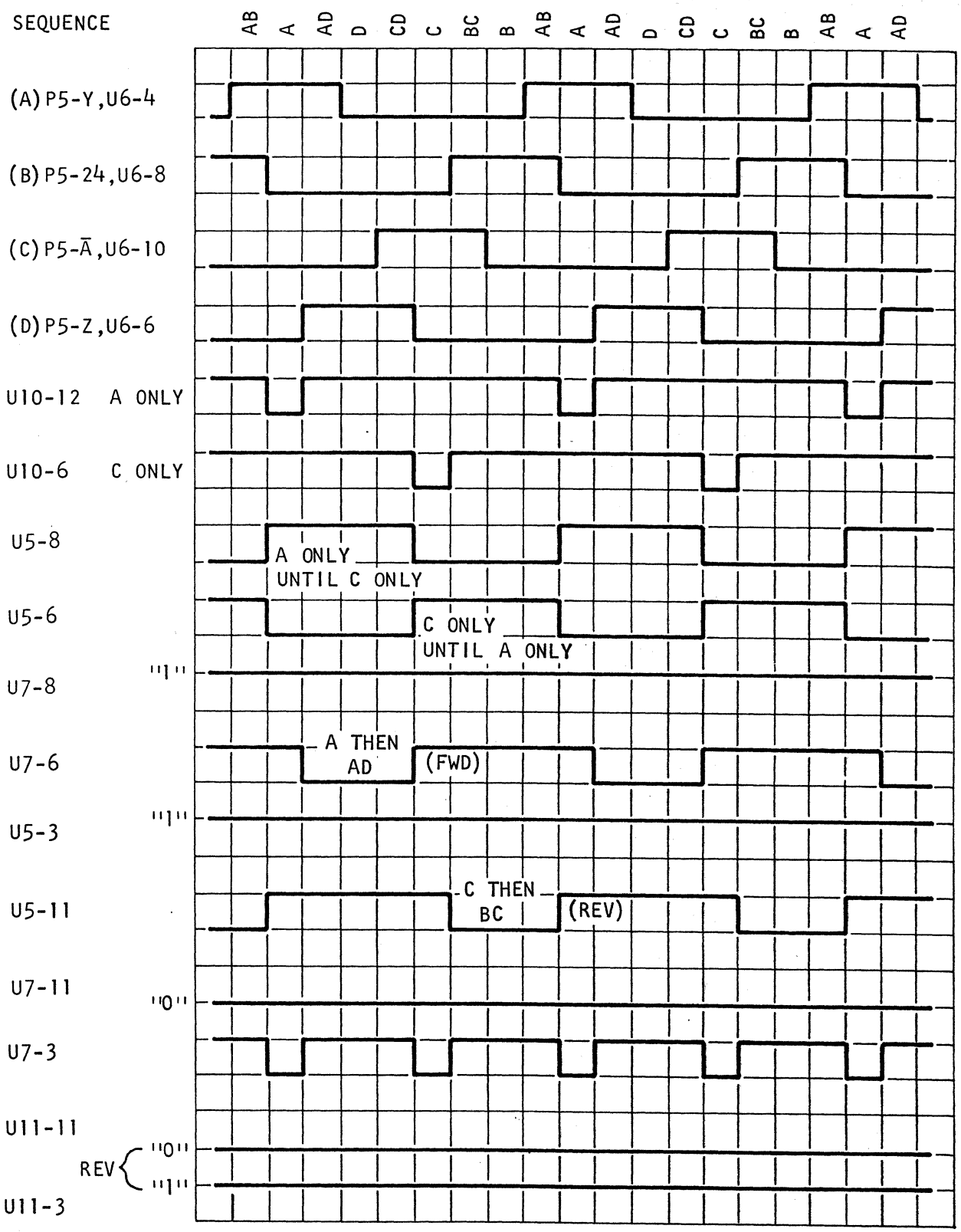


Figure 4-15. Timing Diagram, Direction Sensing Logic, Reverse Direction

4-43. TOO FAST DELAY. The too fast delay circuit controls tape deceleration when the transport is not in the tape mode of capstan servo control. The circuit is shown in the capstan servo block diagram, figure 4-2, between the comparator and the reversing logic. Figure 4-16 is a schematic highlight of the circuit. The input to the too fast delay circuit is derived in the comparator latch circuit described in paragraph 4-27. This signal is a logical "1" for too slow or phase-locked conditions, and a logical "0" for the too fast condition. Inverter U18 inverts the input logic level, while capacitor C20 slows the inverter output response time. Thus, the too fast delay circuit output will be a logical "1" under a too fast condition only after a delay of approximately 3/4 second.

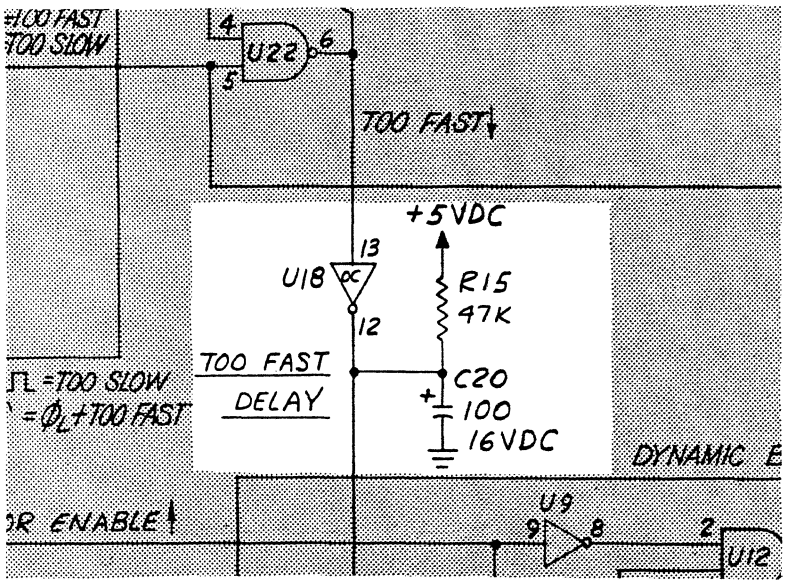


Figure 4-16. Schematic, Too Fast Delay

4-44. REVERSING LOGIC. As shown in figure 4-2, the reversing logic circuit receives inputs from the too fast delay and direction sensing logic circuits, together with run reverse, unloading, tape mode, and fast reverse commands from other sections of the transport. The reversing logic provides outputs which control dynamic braking and the reversing relay. Figure 4-17 is a highlighted schematic diagram of the reversing logic.

4-45. The too fast delay circuit output is connected to NAND gate input U13-1. The other gate input at U13-2 is a logical "0" when in the tape mode of servo control, which holds the gate output (U13-3) at a logical "1", preventing possible reversing relay action during wide phase comparator excursions. Therefore, the logic level at the output of the inverter (U9-10) is always a logical "0" when in the tape mode of servo control. When not in tape mode, the inverter output is a logical "0" for the first 3/4 second of a too fast condition, and a logical "1" thereafter.

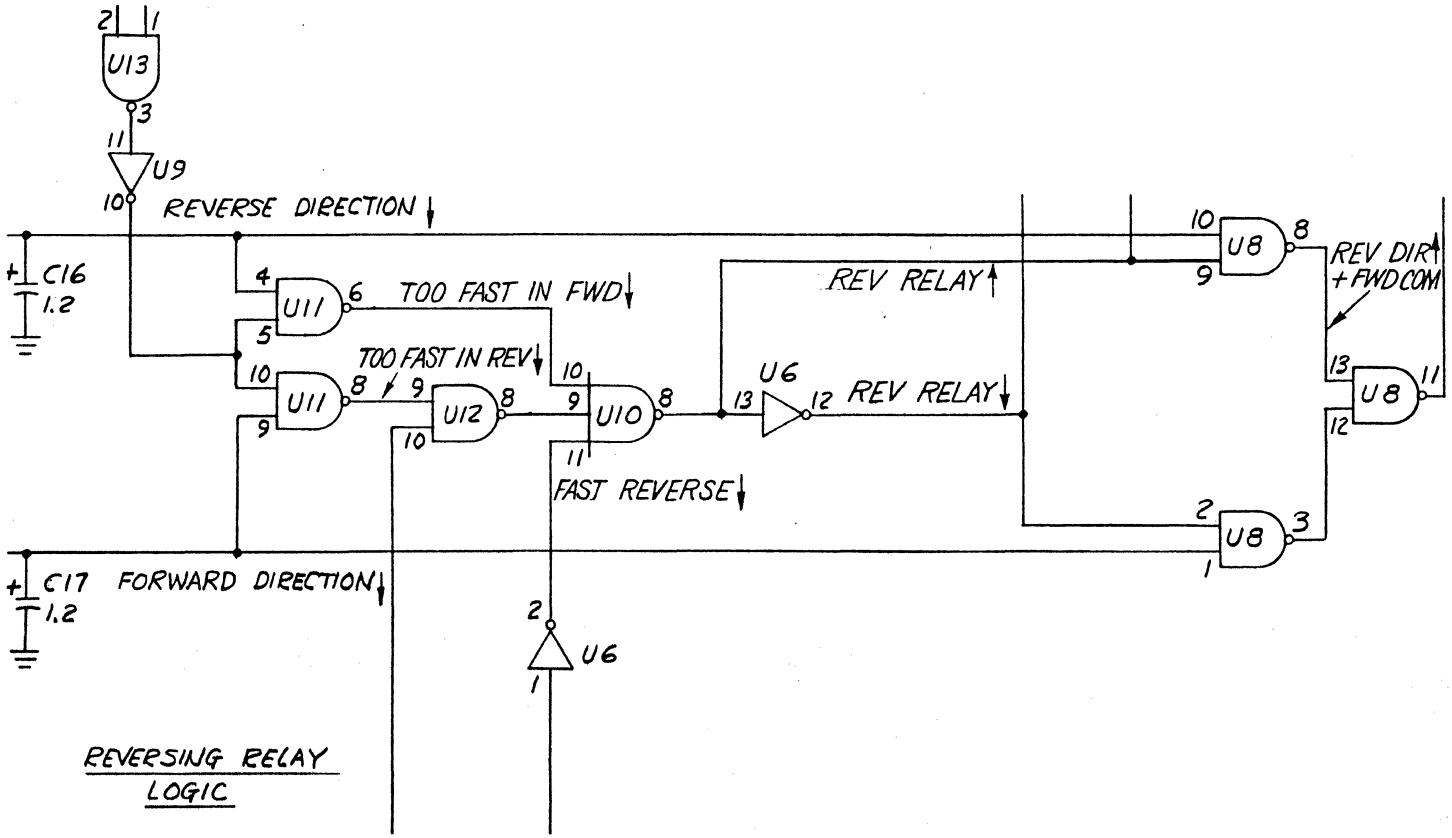


Figure 4-17. Reversing Relay Logic

4-46. The reversing relay is energized when NAND gate output U10-8 is a logical "1". Therefore, the relay is energized when any of the three NAND gate inputs is a logical "0". Input U10-10 is made a logical "0" by NAND gate output U11-6 whenever tape is moving too fast in the forward direction, assuming the transport is not in the tape mode and the 3/4 second too fast delay time has expired. Gate input U10-9 is made a logical "0" by the two preceding NAND gates (outputs U11-8 and U12-8) when the transport is in the nonstandard run reverse mode. (The too fast delay circuit would deenergize the reverse relay after 3/4 second if running too fast in the run reverse mode.) Finally, the reverse relay is energized when the transport is in the fast reverse mode by a logical "0" at NAND gate input U10-11 coming from inverter U6-2. All the conditions under which the reverse relay is energized are summarized below:

a. Too fast in forward direction, while not in tape mode, and after 3/4 second delay.

b. Run reverse (except when too fast).

c. Unloading.

4-47. The remaining portion of the reversing logic consists of the three NAND gates following inverter output U6-12. NAND gate output U8-8 is a logical "1" when the tape is moving in the reverse direction or the reverse relay is not energized (forward command). NAND gate output U8-3 is a logical "1" when the tape is moving in the forward direction or the reverse relay is energized (reverse command). Therefore, NAND gate output U8-11 is a logical "0" when the tape direction agrees with the command, and a logical "1" when they disagree. The gate output will also be a logical "1" when running too fast in the forward direction, while not in tape mode, and after 3/4 second delay. The gate output is connected to the dynamic brake control circuit.

4-48. DYNAMIC BRAKE CONTROL. Figure 4-18 is a highlighted schematic diagram of the dynamic brake control circuit. As shown in the block diagram (figure 4-2), inputs are received from the reversing logic, tach sensing amplifier, comparator enable line, and dynamic brake enable line. Dynamic braking is used when decelerating to a stop or when changing the direction of tape travel.

4-49. When stopping, the comparator is not enabled and NAND gate input U12-2 is a logical "1". Concurrently, if the tape is still moving, gate input U12-1 is also a logical "1". NAND gate input U12-13 will, consequently, be a logical "0", which causes the gate output U12-11 to be a logical "1". This signal is applied to NAND gate input U22-2. With the dynamic braking enabled from the control logic, the other gate input is also a logical "1". Consequently, the gate output (U22-3) is a logical "0", as is the input to the comparator output gate. Thus, the comparator gate output (U22-8) is held at a logical "1" until tape motion stops. This applies full voltage to the capstan motor and assures minimum deceleration time. (The reversing logic reverses the motor polarity.)

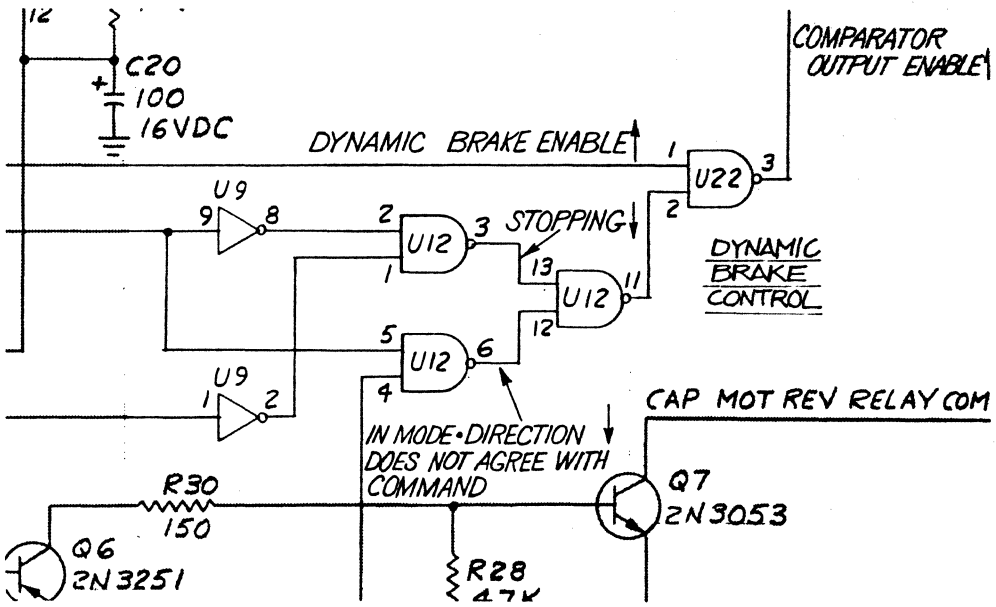


Figure 4-18. Schematic, Dynamic Brake Control

4-50. When the direction of tape movement does not agree with the transport command, the reversing logic applies a logical "1" to NAND gate input terminal U12-4. If, at the same time, the comparator is enabled from the control logic (in a run or fast mode), NAND gate output U12-6 is a logical "0". This causes NAND gate output U12-11 to become a logical "1", NAND gate output U22-3 to become a logical "0", and the comparator gate output (U22-8) to become a logical "1". If in a forward mode, the reversing relay will be energized, or if in reverse, the reversing relay will be deenergized until the direction agrees with the command. Thus, the capstan motor will operate at full voltage until the tape direction agrees with the transport command. NAND gate input U12-4 is also a logical "1" if the transport is running too fast in the forward direction, while not in the tape mode, and after the 3/4 second too fast delay. Thus, the motor will operate at full voltage with reverse torque (after the delay) until the comparator again senses phase lock.

4-51. TACH SENSING AMPLIFIER. The tach sensing amplifier provides an indication of capstan rotation by detecting the tachometer output. The circuit is highlighted in figure 4-19.

4-52. The signal from the tachometer is coupled through resistor R24 and capacitor C18 to the cathode of diode CR1 which provides a discharge path for C18 when the input to C18 goes to ground. The positive portion of the tachometer signal turns on transistor Q5, which produces a logical "0" at its collector. When the capstan is not turning, the collector voltage of Q5 is +5 volts, a logical "1". The time constant of R26 and C19 is larger than the lowest reference period so that C19 cannot charge to +5 volts in the time between Q5 shorting it out and the next cycle. The collector of transistor Q5 is connected to inverter input U9-1 in the dynamic brake control circuit discussed in paragraphs 4-48 through 4-50.

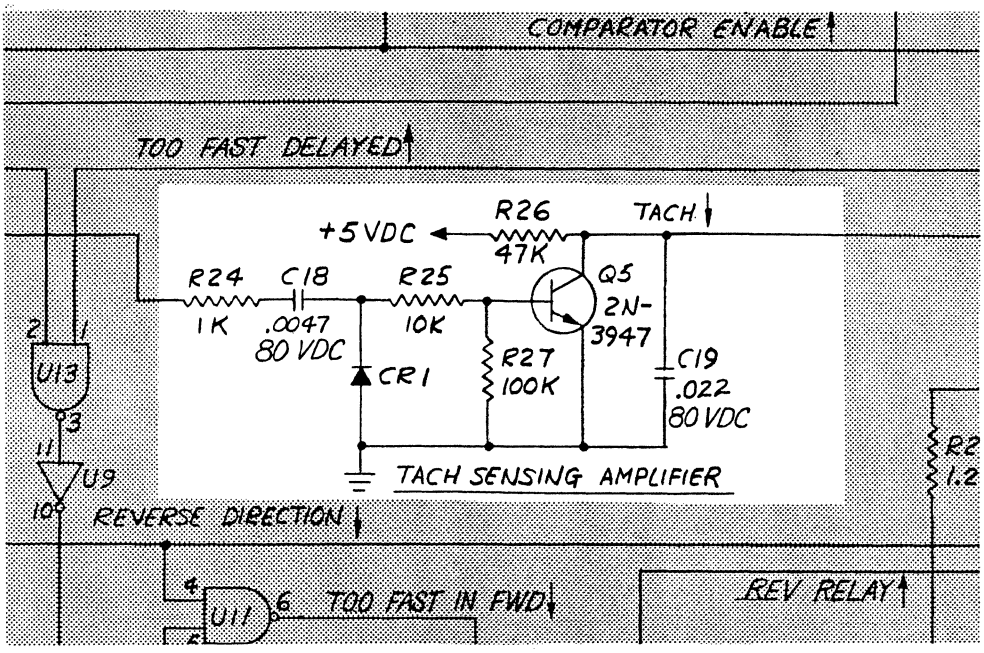


Figure 4-19. Tach Sensing Amplifier

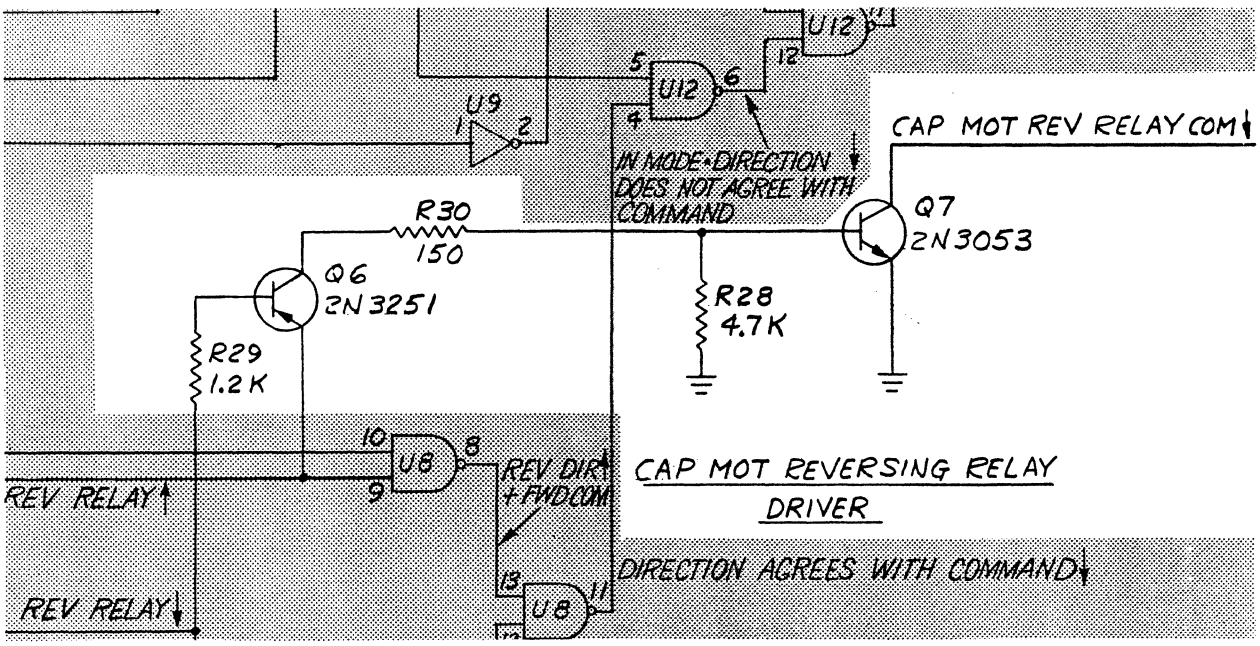


Figure 4-20. Capstan Motor Reversing Relay Driver

4-53. RELAY DRIVER. The relay driver consists of transistors Q6 and Q7 and is shown in figure 4-20. Its purpose is to provide the current gain necessary to drive the capstan motor reversing relay.

4-54. The emitter-base junction of transistor Q6 is connected between the inverter input terminal U6-13 and the inverter output terminal U6-12. When the inverter input is a logical "1", the inverter output is a logical "0". This causes the emitter of transistor Q6 to become more positive than the base, turning the transistor on. When transistor Q6 is turned on, its collector voltage becomes more positive, which turns on transistor Q7. Since the relay coil is connected between +18 volts and the collector of Q7, the relay is energized when Q7 is turned on.

4-55. REEL SERVO SYSTEMS.

4-56. GENERAL. Separate servo systems are used to power the supply and takeup reels. In addition to the normal reeling functions, independent continuous control of tape tension on both the supply and takeup sides of the head area is maintained in all modes of operation. Precision torsion bars serve as the servo references. Near each reel, the tape is threaded through a pair of rollers under tension of the torsion bars. The position of the rollers is determined by the tape tension. Tension sensors attached to each of the two roller assemblies provide the necessary feedback inputs to the reel servo systems.

4-57. A block diagram of a reel servo system is shown in figure 4-21. This circuitry, with the exception of the reel motor and brake solenoid power amplifiers, is a part of the capstan and reel servos printed circuit board, which mates with receptacle A1J5. The power amplifiers are located on the transport plate, which serves as a heat sink. Figure 7-1 is the schematic diagram of the transport assembly. The reel servo circuitry is highlighted in figure 4-22. Except as noted, the supply and takeup servo circuits are identical.

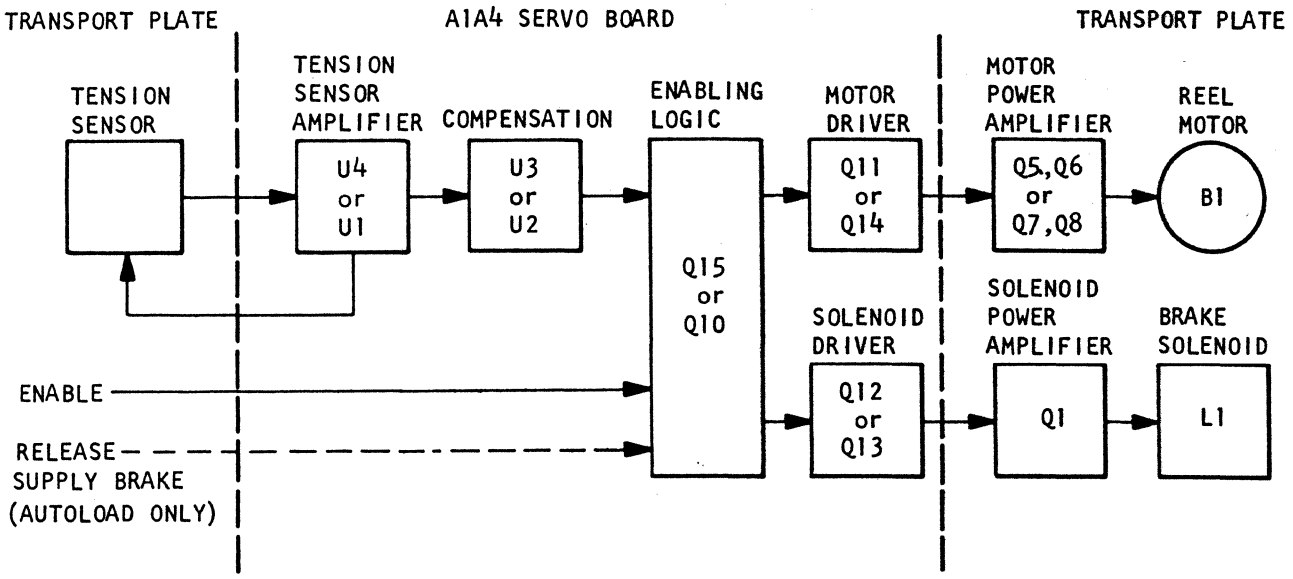


Figure 4-21. 12-401D Reel Servo System

4-58. TENSION SENSORS. Tension of the tape threaded through each pair of sensing rollers is sensed by detecting the amount of light from a light-emitting diode which reaches a phototransistor through a variable density shutter. The amount of light reaching the phototransistor is inversely proportional to the tape tension. Current flow within the transistor is proportional to the amount of light reaching it. Therefore, when the tape tension is low, more light strikes the phototransistor and the emitter voltage is more positive than it would be with a higher tape tension. The emitter voltages are the inputs of the tension sensing amplifiers.

4-59. TENSION SENSOR AMPLIFIERS. The tension sensor phototransistor emitter voltages are applied to the inverting inputs (terminal 2) of integrated circuit operational amplifiers. The supply amplifier is U4 and the takeup amplifier is U1. An adjustable offset is provided at the noninverting inputs of the amplifiers (terminal 3). The offset voltage ranges from -3 volts to +3 volts, depending upon the setting of potentiometer R53 or R70. With the torsion bar tension previously established, the offset potentiometers are adjusted such that the two rollers of each tension sensing assembly are positioned horizontally.

4-60. COMPENSATION. The circuits which follow the tension sensor amplifiers tailor the responses of the reel servo systems to the inertia characteristics of the reel motors. The compensation for each reel servo system is provided by two RC networks. The first network is between the output of the tension sensor amplifier (terminal 6) and the inverting input of an operational amplifier (terminal 2). The second compensation network forms a negative feedback loop from the amplifier output to the inverting input. The noninverting inputs (terminal 3) of both the supply and takeup compensation amplifiers are referenced to ground through 4.7K ohm resistors. Test points at the output of the amplifiers are provided to aid in troubleshooting. Test point TP4 monitors the supply servo and TP5 monitors the takeup servo.

4-61. ENABLING LOGIC. The enabling logic is between the compensation and driver circuits. A logical "0" must be present on the supply and takeup enable lines from the control logic circuitry in order to energize the reel motors and brake solenoids. When a logical "1" is present on either line, transistor Q15 or Q10 will be turned on and the compensation amplifier output will be shunted to ground via diode CR10 or CR12. At the same time, the anodes of diode CR11 or CR13 will be at ground potential, which turns off the corresponding brake solenoid driver transistor (Q12 or Q13).

4-62. The supply brake solenoid circuitry may be turned on independently of the reel motors and takeup brake solenoid by a logical "1" on the release supply brake line from the control logic through diode CR14.

4-63. In a normal mode of operation, with the reel motors energized and the brakes retracted, the supply and takeup enable lines are both a logical "0". The ground potential at the bases of transistors Q15 and Q10 turns them off. This allows the signals from the outputs of the compensation amplifiers to be coupled to the inputs of the motor driver stages (Q11 and Q14). In addition, the positive potential at the collectors of transistors Q15 and Q10 is coupled through diodes CR11 and CR13, which turns on solenoid driver transistors Q12 and Q13.

4-64. REEL MOTOR DRIVERS. The supply and takeup reel motor drivers consist of transistors Q11 and Q14, respectively. The emitter-follower configurations provide current gain to drive the reel power amplifiers from the tension signals coming from the compensation amplifiers, U3 and U2. As shown in figure 4-22, connections are made through connector A1P5 on the capstan and reel servo board to the power amplifier stages mounted on the transport plate.

4-65. BRAKE SOLENOID DRIVERS. The supply and takeup brake solenoid drivers consist of transistors Q12 and Q13, respectively. The emitter-follower configurations provide current gain to drive the brake solenoid power amplifiers. The drivers are turned on when the servos are enabled. As shown in figure 4-22, connections are made through connector A1P5 on the capstan and reel servo board to the power amplifier stages mounted on the transport plate.

4-66. REEL MOTOR POWER AMPLIFIERS. The power amplifiers are shown schematically in both figures 4-22 and 7-3. Both the supply and takeup amplifiers consist of a cascaded pair of transistors in a Darlington configuration. The first transistor provides current gain to drive the second. The final transistor is essentially in series with the reel motor and, therefore, determines the voltage across the motor. Tape tension is controllable because the motor torque is dependent on the motor voltage. The motor polarity is such that the supply motor torque is in a clockwise direction and the takeup motor torque is in a counterclockwise direction.

4-67. BRAKE SOLENOID POWER AMPLIFIERS. The power amplifiers are shown schematically in both figures 4-22 and 7-3. Both essentially consist of a switching transistor which, when turned on by the solenoid driver, completes a current path from the solenoid to ground. A 20 ohm resistor is in series with the solenoid and the +18 volt power. This resistor is initially bypassed by contacts of a switch. The solenoid, when energized, mechanically actuates the switch, which opens the contacts and inserts the resistance. This feature conserves power and avoids solenoid overheating, since the solenoid holding current requirement is less than the actuation current. The brakes are released when the solenoids are energized. Thus, the brakes prevent tape damage in case of a power failure, when the normal dynamic braking is ineffective. Diodes across the solenoids suppress transients when the solenoids are deenergized.

4-68. TRANSPORT CONTROL LOGIC.

4-69. GENERAL. The control logic circuits store operator commands and control all modes of tape transport operation. Figure 4-23 is a block diagram of the control logic. All the circuits for the standard transport are contained on the control logic circuit card shown schematically in figure 7-2. Figure 7-4 is the transport connector schematic. Figure 7-5 is a schematic presentation of the transport terminal cards.

4-70. 8 MHz Oscillator. An 8 MHz oscillator is the source of both the bias and capstan servo reference frequencies. It consists of two NAND gates coupled in series by capacitor C37. Positive feedback from the output of the second NAND gate (U1-11) to the input of the first NAND gate (U1-9 and U1-10) is provided through the 8 MHz crystal Y1 and trimmer capacitor C35. The trimmer capacitor is adjusted for stable operation at 8 MHz. Resistor R64 and capacitors C36 and C38 prevent the 8 MHz from coupling into the +5 volt NAND gate power supply. A third NAND gate, the output of which is U1-3, serves as a buffer between the oscillator and the frequency dividers.

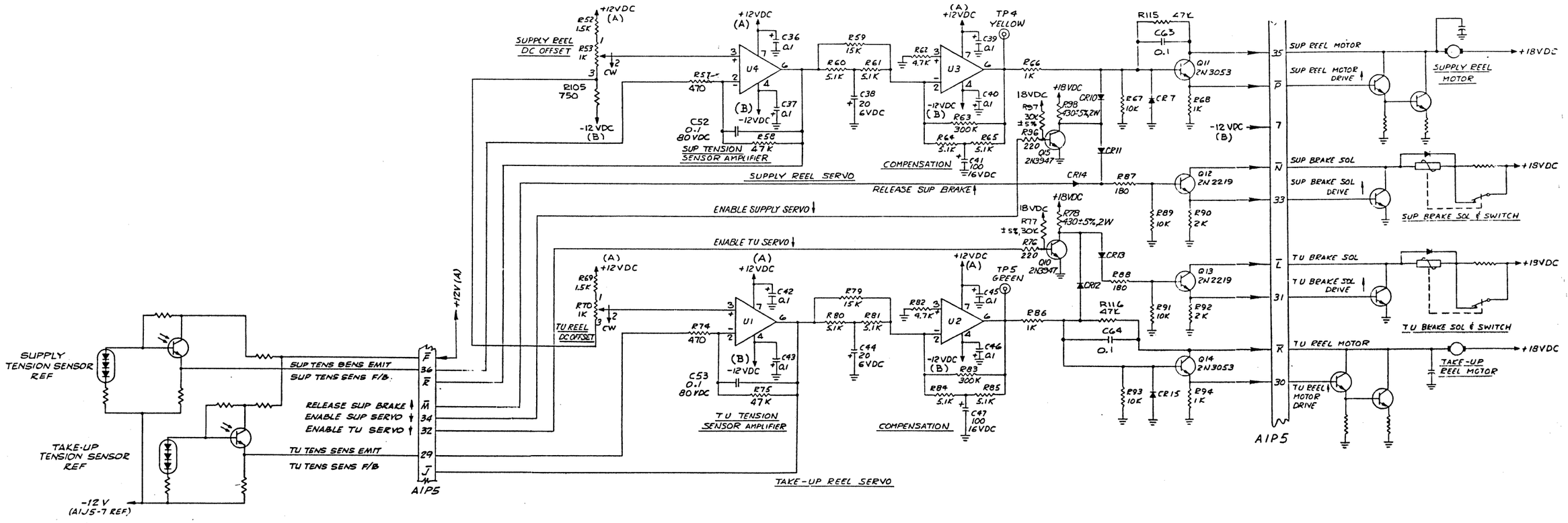


Figure 4-22. Schematic, Reel Servo

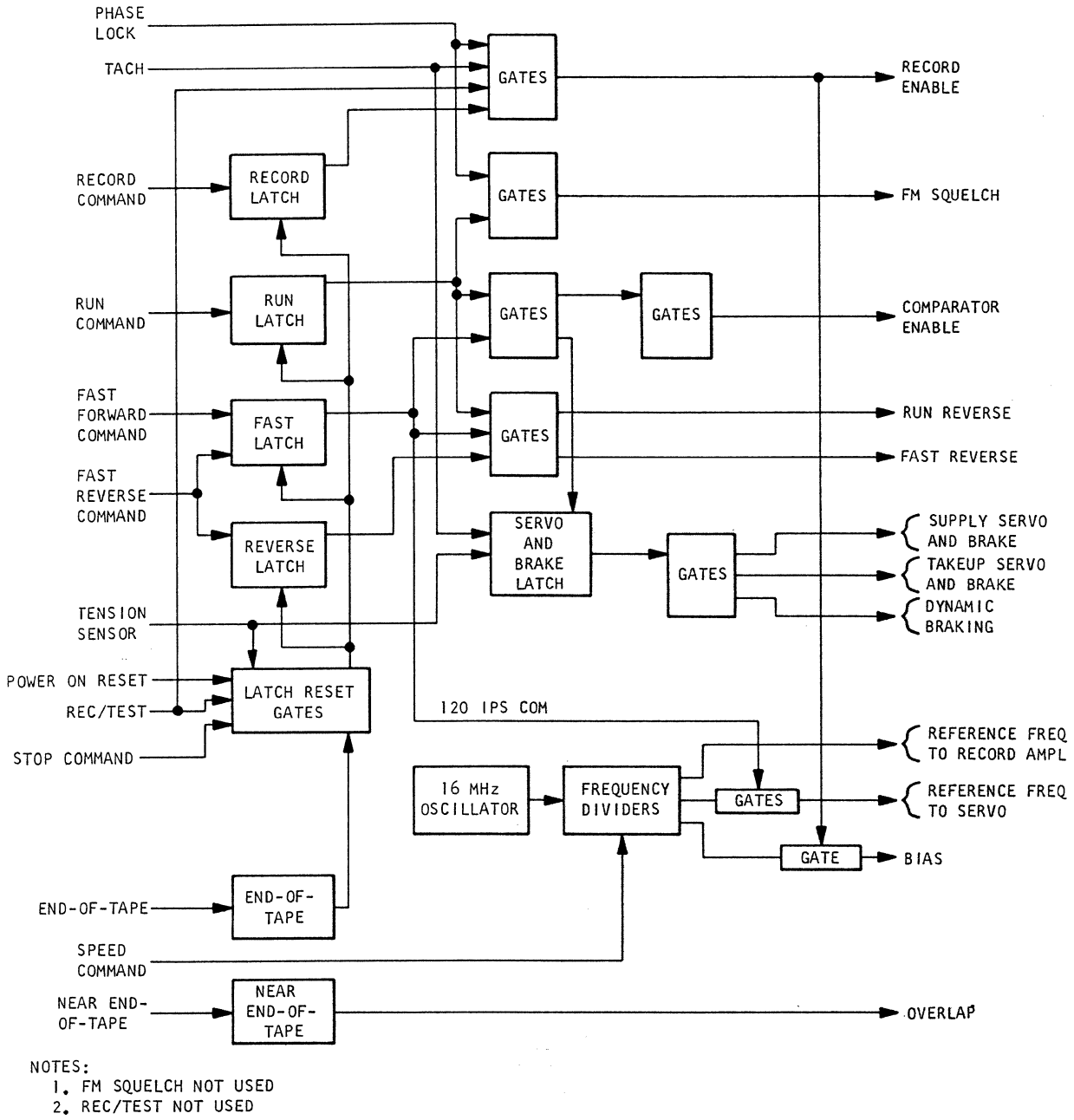


Figure 4-23. Block Diagram, Transport Control Logic

4-71. FREQUENCY DIVIDERS. In order to provide appropriate bias and servo reference frequencies, the 8 MHz signal from the oscillator is fed to a chain of frequency dividers. The first two dividers are each conventional integrated circuit flip-flops. When connected as shown in the schematic on figure 7-2, each flip-flop divides the frequency at its input by two. Therefore, the frequencies available at terminals E4 and E5 are 4 MHz and 2 MHz, respectively. To provide the bias normally used in the system, a jumper is connected between E4 and E3. The bias frequency is applied to NAND gate input U1-4. When the record enable line at U1-5 is a logical "1", the bias will be gated to connector pin A1P4-A. From this point, the bias is routed to the amplifier mother board for distribution to the direct record amplifiers. Bias is also provided at connector pin A1P4-1, for use in the optional voice logging unit during all modes of operation independent of the record enable line.

4-72. The remaining divider stages provide the appropriate capstan servo reference frequencies for each tape speed. The divider block labeled U7 is a self-contained integrated circuit decade counter (SN7490). It divides the 2 MHz frequency at U4-9 by 10, providing a 200 kHz reference frequency. The 200 kHz frequency is gated to the capstan servo system in the fast modes to provide 120 inches per second tape speed in the fast forward and fast reverse modes of operation.

4-73. The last eight divider stages in the frequency divider circuit each divide the input to it by two. This provides the reference frequencies for 60 ips operation through 15/32 ips operation. The appropriate reference frequency is selected by the TAPE SPEED SELECTOR switch, S1, which enables one of the NOR gates at the flip-flop outputs and allows the reference frequency to be gated to connector pin A1P4-H on the circuit board. From this point, the reference frequency is routed to the amplifier mother board as the input to the tape lock servo option for recording the reference frequency on a direct record/reproduce channel.

4-74. The selected reference frequency is also connected to NAND gate input U10-1. In the run mode, it is gated to connector pin A1P4-F. From this point, the signal is routed to the capstan servo board at A1J5-16 to provide the phase comparator reference. In fast forward or fast reverse mode, the reference frequency is 200 kHz (120 ips).

4-75. RECORD ENABLE AND SQUELCH. The record enable line energizes the signal record electronics. The record enable line at NAND gate output U12-8 is a logical "1" when enabled. Enabling requires that the transport be in phase lock and in the record mode. Thus, both NAND gate inputs U12-12 and U12-13 must be a logical "1". The record electronics cannot be enabled until the tape is moving at the correct speed.

4-76. The record electronics are also energized when the transport is in the record test mode, providing that there is no tape motion. Under these conditions, NAND gate inputs U12-4 and U12-5 are both logical "1". Tape motion is sensed by a tachometer sensing amplifier.

4-77. The tachometer sensing amplifier circuit consists of transistor Q19 and associated components. Tachometer pulses from the capstan motor enter the control logic board at connector pin A1P4-7 and are coupled through resistor R63 and capacitor C39 to the cathode of diode CR4, where the negative half-cycles are shunted to ground through the diode. The positive half-cycles are coupled to the base of transistor Q19, turning it on. The time constant of R69 and C40 is larger than the lowest reference period so that C40 cannot charge to +5 volts between the reference pulses. Therefore, when the capstan motor is turning, the transistor collector voltage is a logical "0".

4-78. Squelch is used to disable the FM reproduce amplifiers when not in a run mode and phase lock, in order to prevent the generation of noise in the demodulator due to an absence of carrier signal. The output of NAND gate U12-3 is a logical "0" when in run mode and phase lock. The output of U12-3 is routed through connector pin A1P4-E to the amplifier mother boards for distribution to the FM reproduce amplifiers.

4-79. RUN FORWARD MODE. Figure 4-24 is a simplified drawing of the run forward mode logic. The transport is placed in the run forward mode by pressing the RUN FORWARD pushbutton (switch S4). When not in remote, U24-3 is held high by R65, therefore, the local feed line is a logical "0". The normally open contacts of switch S4 apply this logical "0" from the local feed line through resistor R40 to NAND gate input terminal U17-13. The RC network of R39 and C27 prevents spikes that might appear at E14 when S4-6 is open from falsely triggering RUN FORWARD. Resistor R40 limits the charge current of C27 when the RUN FORWARD pushbutton is pressed. (This circuit is typical of all mode command input lines.) This causes the gate output (U17-11) to become a logical "1" and the following inverter output (U20-8) a logical "0". The logical "0" at NAND gate input U14-11 causes the gate output (U14-8) to become a logical "1" and the following inverter output (U20-10) a logical "0".

4-80. The run latch circuit consists of two cross-coupled NAND gates. The logical "0" from inverter U20-10 causes gate output U15-6 to become a logical "1". Therefore, inverter output U16-6, the run reset line, is a logical "0". NAND gate inputs U14-3 and U14-5 are both a logical "1" when the reset line is not enabled and the transport is not in a fast mode. Therefore, NAND gate output U14-6 becomes a logical "0", as is NAND gate input U15-4, holding the latch set after the RUN FORWARD pushbutton is released. Inverter output U11-2, the run memory line, is a logical "1". The run latch circuit will remain in the aforementioned set condition until one of NAND gate inputs U14-3 or U14-5 becomes a logical "0".

4-81. With the run latch set, NOR gate input U18-2 is a logical "0". When the reverse latch is not set, NOR gate input U18-3 is also a logical "0". Therefore, the gate output is a logical "1" and transistor Q13 is turned on, which illuminates lamp DS4 behind the RUN FORWARD pushbutton.

4-82. The transport may be placed in the run forward mode from a remote location with a logical "0" (ground) at connector A1P4-T. Provision is also made for illuminating a remote run forward lamp through connector pin 15.

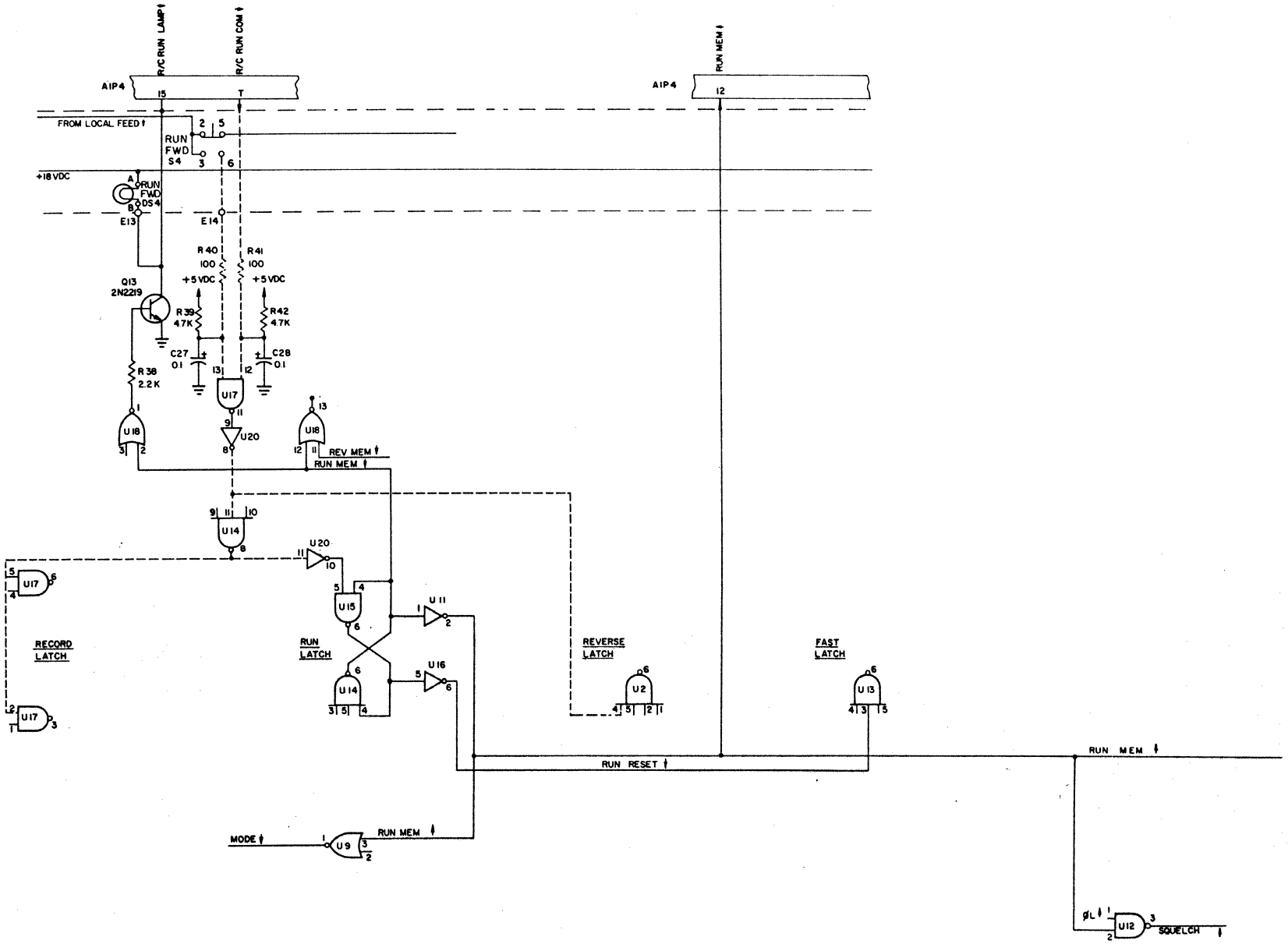


Figure 4-24. Run Forward Mode Logic

4-83. An overlap signal (a logical "0") from another transport at connector A1P4-U will place the transport in the run forward mode through NAND gate input U14-9. The overlap signal also sets the record latch by a connection through diode CR3.

4-84. The run memory signal from inverter output U11-2 is used to enable the servo reference frequency at NAND gate input U10-2.

4-85. RUN REVERSE MODE. Figure 4-25 is a simplified drawing of the run reverse mode logic. The transport is placed in the run reverse mode by pressing RUN REVERSE pushbutton switch S8. Normally open contacts of switch S8 apply a logical "0" from the local feed line through resistor R45 to NAND gate input terminal U15-2. This causes the gate output (U15-3) to become a logical "1" and the following inverter output (U16-4) a logical "0".

4-86. The reverse latch circuit consists of two cross-coupled NAND gates. The logical "0" from inverter U16-4 causes latch gate output U14-12 to become a logical "1". Since latch gate inputs U2-2, U2-4, and U2-5 are all logical "1", the second gate output (U2-6) is a logical "0" and the latch circuit is set. It will remain in this condition until one of NAND gate inputs U2-2, U2-4, or U2-5 goes to a logical "0", as when entering a stop or run forward mode. In addition to setting the reverse latch, the logical "0" from inverter U16-4 also causes the output of U14-8 to become a logical "1", and the following inverter output (U20-10) becomes a logical "0".

4-87. The run latch circuit consists of two cross-coupled NAND gates. The logical "0" from inverter U20-10 causes gate output U15-6 to become a logical "1". Therefore, inverter output U16-6, the run reset line, is a logical "0". NAND gate inputs U14-3 and U14-5 are both a logical "1" when the reset line is not enabled and the transport is not in a fast mode. Therefore, NAND gate output U14-6 becomes a logical "0", as is NAND gate input U15-4, holding the latch set after the RUN REVERSE pushbutton is released. The run latch circuit will remain set until one of the NAND gate inputs U14-3 or U14-5 becomes a logical "0".

4-88. With both the run and reverse latches set, NOR gate inputs U18-11 and U18-12 are logical "0". Therefore, NOR gate output U18-13 is a logical "1" and transistor Q14 is turned on, illuminating lamp DS10 behind the RUN REVERSE pushbutton.

4-89. The transport may be placed in a run reverse mode from a remote location with a logical "0" at connector A1P4-L. Provision is also made for illuminating a remote run reverse lamp through connector pin A1P4-13.

4-90. RECORD MODE. Figure 4-26 is a simplified drawing of the record mode logic. The transport is placed in the record mode by simultaneously pressing the RECORD and either RUN FORWARD or RUN REVERSE pushbuttons and by releasing the RECORD pushbutton last. The run latch is set by switch S4 as described in paragraphs 4-81 and 4-82. Normally open contacts of the RECORD switch S3 apply a logical "0" from the local feed line through resistor R33 to NAND gate input terminal U21-1. This causes the gate output (U21-12) to become a logical "1", which is applied to NAND gate input U17-4. The other gate input (U17-5) is also a logical "1", because the RUN FORWARD or RUN REVERSE pushbutton is depressed. Therefore, NAND gate output U17-6 becomes a logical "0".

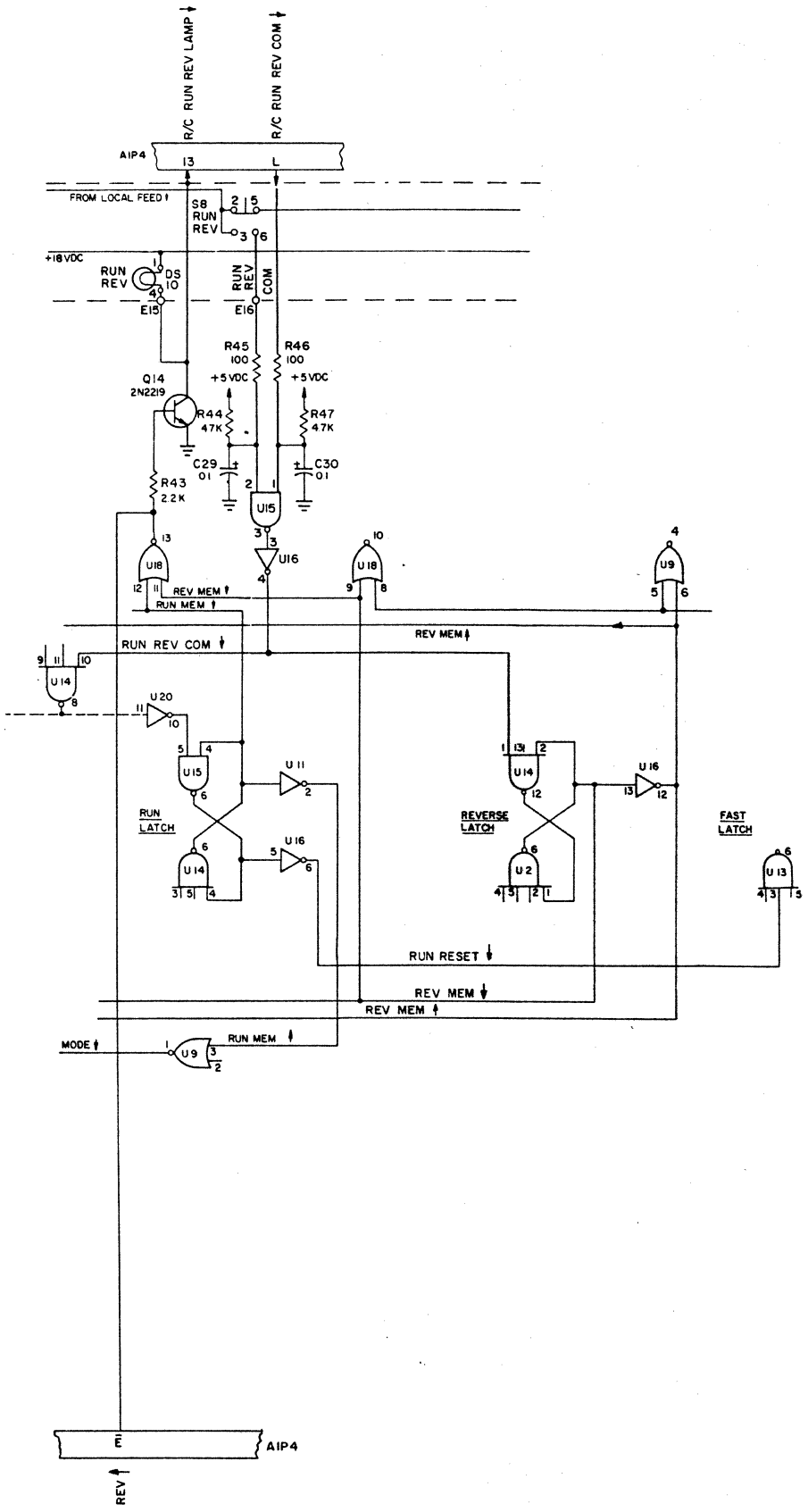


Figure 4-25. Run Reverse Mode Logic

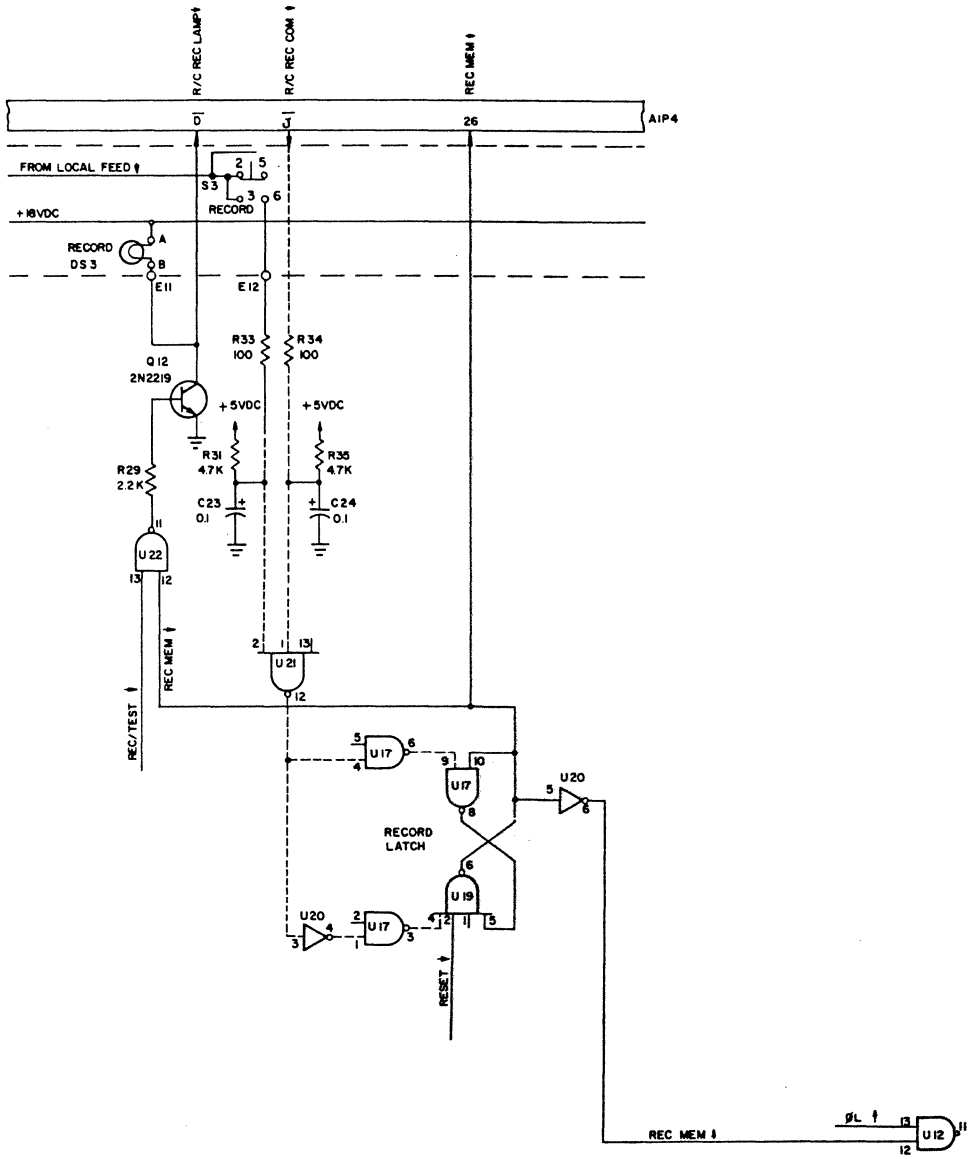


Figure 4-26. Record Mode Logic

4-91. The record latch circuit consists of two cross-coupled NAND gates. The logical "0" from NAND gate output U17-6 causes latch gate output U17-8 to become a logical "1". Since latch gate inputs U19-1, U19-2, U19-4, and U19-5 are all logical "1", the second gate output (U19-6) is a logical "0" and the latch circuit is set, allowing the pushbuttons to be released. Inverter U20 ensures that the latch circuit remains set if the RECORD pushbutton is released last. Should the RECORD pushbutton be released first, the input to U20 becomes a logical "0" which is inverted to a logical "1" input to U17-1. This causes the gate output (U17-3) to become a logical "0" since the other input (from the RUN FORWARD or RUN REVERSE pushbutton) is still a logical "1". The record latch is then reset when the RECORD pushbutton is released first. Once in the set condition, it will remain set until one of the NAND gate U19 inputs becomes a logical "0", as when stopping (U19-2), in a fast mode (U19-1), or when only the RUN pushbutton is depressed (U19-4). Pressing only the RUN FORWARD pushbutton causes U17-11 to be a logical "1", U20-8 to be a logical "0", and U14-8 to be a logical "1" which appears at U17-2. Since the RECORD pushbutton is not being depressed, U17-1 is also a logical "1". Therefore, U17-3 is a logical "0", resetting the record latch.

4-92. With the record latch set, NAND gate input U22-12 is a logical "0". Therefore, the gate output is a logical "1" and transistor Q12 is turned on, which illuminates lamp DS3 behind the RECORD pushbutton. The lamp will also be on when in the record test mode, with a logical "0" at NAND gate input U22-13.

4-93. The transport may be placed in the record mode from a remote location with a logical "0" (ground) at connector A1P4, pins $\overline{J}$ and T. Provision is also made for illuminating a remote record lamp through connector pin $\overline{D}$.

4-94. NAND gate input U21-13 is used to set the record latch when the overlap feature is employed. In normal transport local operation, the RECORD pushbutton must be released last. In overlap transfer of the record mode, this delay is achieved by capacitor C25 holding U21-13 low for a short time after the overlap command has disappeared.

4-95. The record memory logical "1", from inverter output U20-6, is connected to NAND gate input U12-12 as one of the conditions for enabling the data signal record electronics.

4-96. FAST FORWARD MODE. Figure 4-27 is a simplified drawing of the fast forward mode logic. The transport is placed in the fast forward mode by pressing the FAST FORWARD pushbutton switch S6. Normally open contacts of the switch apply a logical "0" from the local feed line through resistor R58 to NAND gate input terminal U15-10. This causes the gate output (U15-8) to become a logical "1" and the following inverter output (U16-8) a logical "0".

4-97. The fast latch circuit consists of two cross-coupled NAND gates. The logical "0" from inverter U16-8 causes latch gate output U13-8 to become a logical "1". Since latch gate inputs U13-3 and U14-4 are a logical "1", the second gate output (U13-6) is a logical "0" and the latch circuit is set. It will remain in this condition until one of NAND gate inputs U13-3 or U14-4 goes to logical "0", as when stopping or entering a run mode.

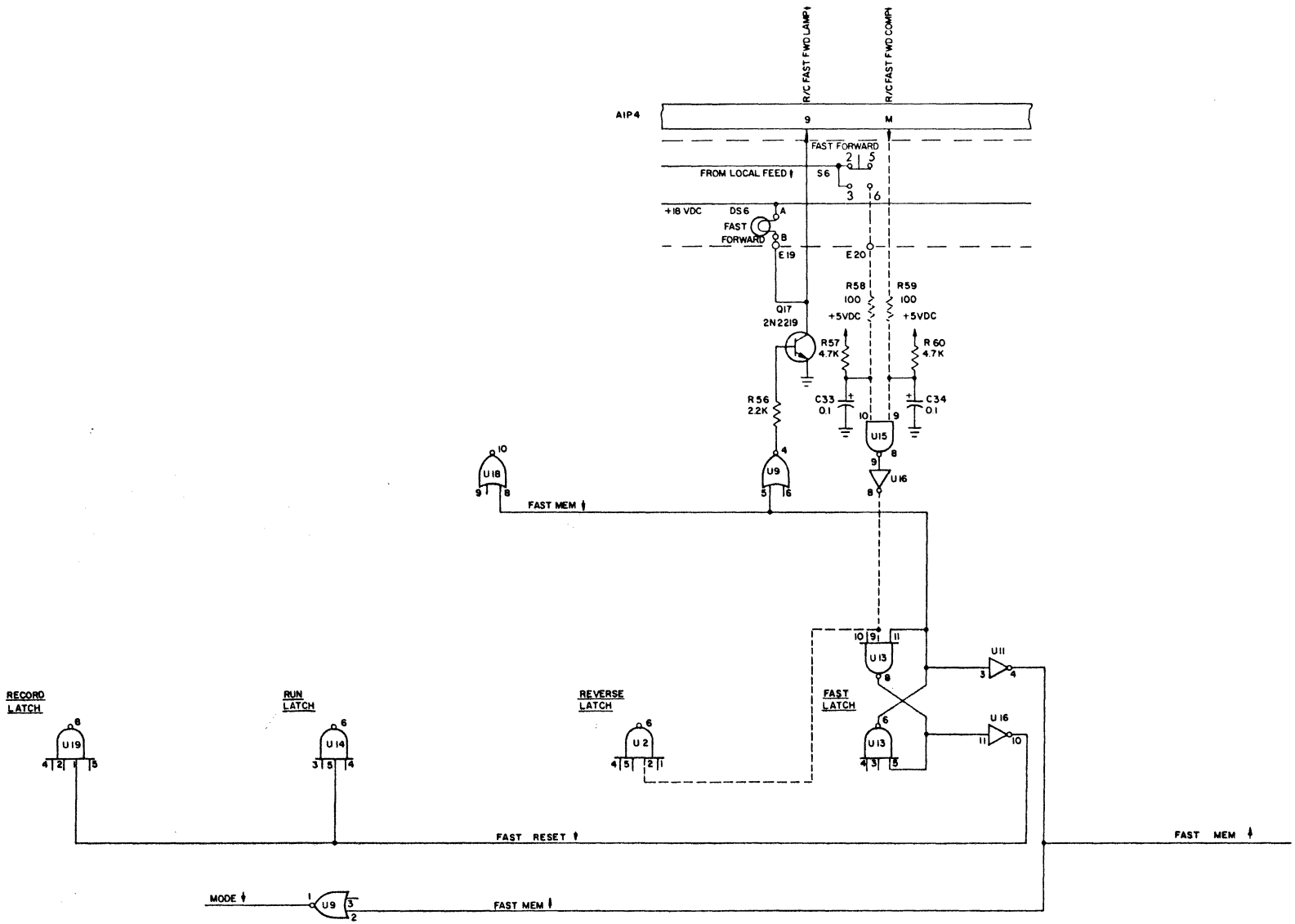


Figure 4-27. Fast Forward Mode Logic

4-98. With the fast latch set, NOR gate input U9-5 is a logical "0". When the reverse latch is not set, NOR gate input U9-6 is also a logical "0". Therefore, the gate output is a logical "1" and transistor Q17 is turned on, which illuminates lamp DS6 behind the FAST FORWARD pushbutton.

4-99. The transport may be placed in the fast forward mode from a remote location with a logical "0" (ground) at connector pin A1P4-M. Provision is also made for illuminating a remote fast forward lamp through connector pin A1P4-9.

4-100. The fast memory logical "1" from inverter output U11-4 is connected to NAND gate input U10-12 to select a 200 kHz servo reference frequency in the fast modes. (A 200 kHz reference frequency provides a fast tape speed of 120 ips.)

4-101. FAST REVERSE MODE. Figure 4-28 is a simplified drawing of the fast reverse mode logic. The transport is placed in the fast reverse mode by pressing the FAST REVERSE pushbutton switch S5. Normally open contacts of the switch apply a logical "0" from the local feed line through resistor R52 to NAND gate input terminal U15-12. This causes the gate output (U15-11) to become a logical "1" and the following inverter output (U16-2) a logical "0".

4-102. The reverse latch circuit consists of two cross-coupled NAND gates. The logical "0" from inverter U16-2 causes latch gate output U14-12 to become a logical "1". Since latch gate inputs U2-2, U2-4, and U2-5 are all logical "1", because run and fast forward are not commanded, the second gate output (U2-6) is a logical "0" and the latch circuit is set. It will remain in this condition until one of the second NAND gate inputs goes to logical "0", as when stopping or receiving a run or fast forward command.

4-103. In addition to setting the reverse latch, the fast reverse command from inverter U16-2 also sets the fast latch, by means of a connection to NAND gate input U13-10.

4-104. With both the fast and reverse latches set, NOR gate inputs U18-8 and U18-9 are a logical "0". Therefore, the gate output is a logical "1" and transistor Q15 is turned on, which illuminates lamp DS5 behind the FAST REVERSE pushbutton.

4-105. The transport may be placed in the fast reverse mode from a remote location with a logical "0" (ground) at connector pin A1P4-P. Provision is also made for illuminating a remote fast reverse lamp through connector pin A1P4-10.

4-106. STOP. Tape motion may be stopped from any mode by pressing the STOP pushbutton switch S2. Normally open contacts on the switch apply a logical "0" from the local feed line through resistor R26 to NAND gate input terminal U19-9. This causes the gate output (U19-8) to become a logical "1", and the following NOR gate output (U23-10) a logical "0". Since the NOR gate output is an input to the second NAND gate in each latching circuit, any latch which was previously set is reset by the stop command. In the remote mode of operation, the transport may be stopped manually with a logical "0" at connector pin A1P4-Y.

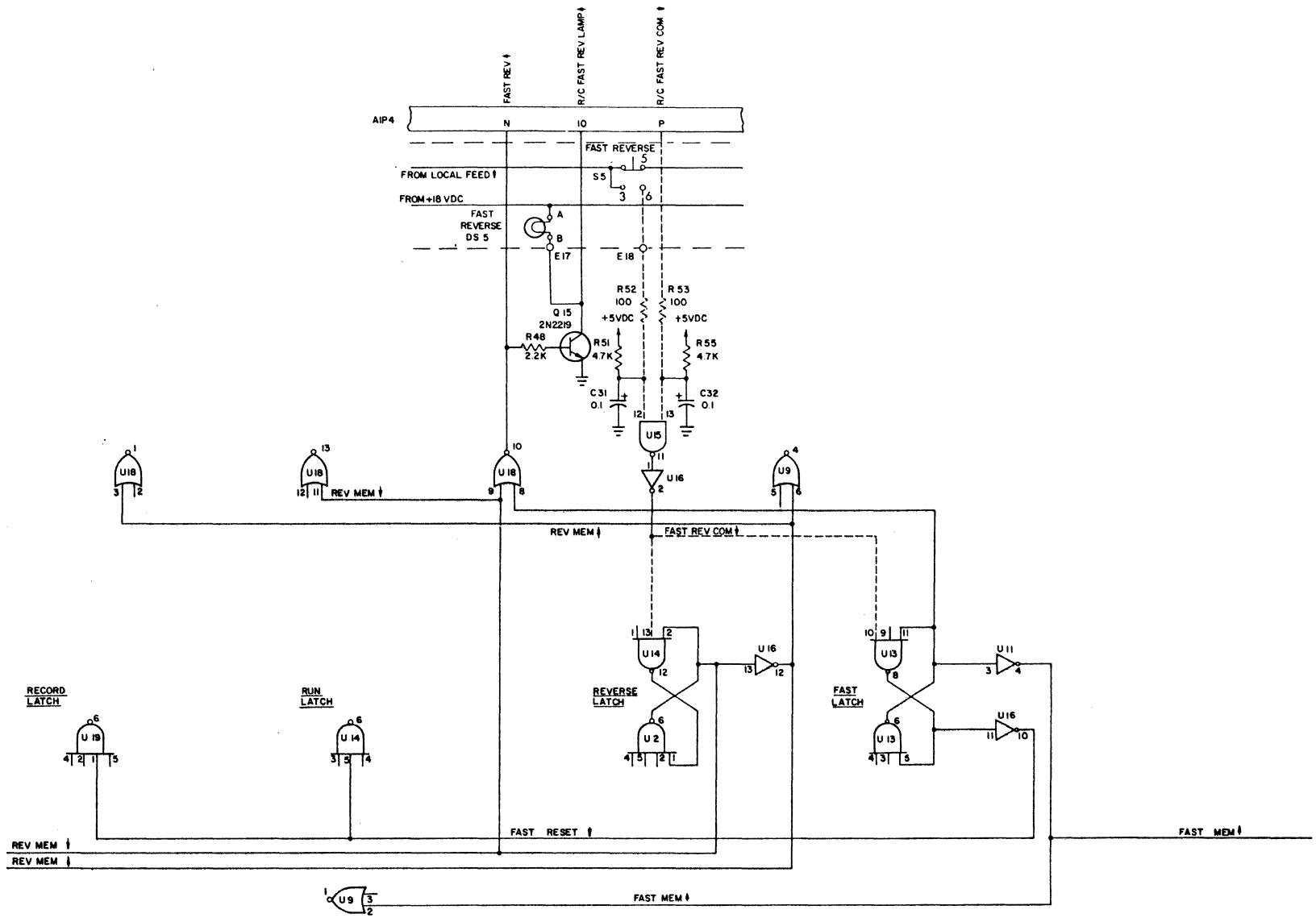


Figure 4-28. Fast Reverse Mode Logic

4-107. The transport is stopped automatically at the end of tape by a logical "0" at NAND gate input U19-10. The sensor logic is described in paragraph 4-116. Also, the transport is stopped automatically when the TAPE SPEED SELECTOR switch S1 is first placed in the remote position. The wiper of switch S1 applies a logical "0" to the remote feed line which is ac coupled via C22 to the mode latch reset line. Resistors R30 and R32 maintain the inputs to the following gates at a voltage the minimum logical "1" level of 2.4 volts when the reset pulse has gone.

4-108. The transport mode latches are also reset when the power is off and during the first few milliseconds after power is turned on by a connection to NAND gate input U19-12. The power-on reset circuit is discussed in paragraph 4-115.

4-109. The mode latches are also reset by a logical "1" at NOR gate input U23-9. This line, which is NAND gate output U21-8, will be a logical "1" when there is a loss of tape tension or when the RECORD TEST switch is on.

4-110. Lamp DS2 behind the STOP pushbutton is illuminated by transistor Q11 and NOR gate output U23-1, providing the transport is not in any mode of tape motion and the tape is under tension. A remote stop lamp may also be illuminated by a connection through connector pin A1P4-Z.

4-111. READY. The transport is in a READY condition when the same conditions that illuminate the STOP pushbutton are met, except that tape motion does not extinguish the READY lamp. When both the STOP and READY lamps are extinguished, the cause could be loss of tape tension or loss of power.

4-112. NO TENSION SENSING. Provision is made to stop tape motion as a loss of tape tension occurs. The circuit is shown on the left-hand side of figure 7-2.

4-113. Two switches in the supply and takeup tension sensor assemblies detect a complete loss of tape tension. The circuits for the two tension switches are shown as part of the transport assembly schematic diagram, figure 7-3. The supply tension switch is A1A2A1S1 and the takeup tension switch is A1A2A2S1. Both switches are closed when the tape is threaded properly and under tension. They are connected in series between +5 volts and pin A1P4-22 on the control logic circuit. A jumper between terminals E1 and E2 connects pin 22 through resistor R1 to the base of transistor Q1. Transistor Q1 is turned on by the positive base voltage and the $\overline{\text{TEN}}$ line is kept at a logical "0". This level is inverted at inverter U20-2 to become a logical "1". This line is connected to the stop logic at NAND gate input U21-11. (The gate is described in paragraph 4-109.) It is also connected to the reset input of the servo and brake enabling latch.

4-114. SERVO AND BRAKE ENABLING LATCH. The servo and brake enabling latch is used to enable both the supply and takeup reel motors and associated brake solenoids. The latch circuit consists of two cross-coupled NAND gates. The latch is set in a run or fast mode by a logical "0" at NAND gate input U22-4. This causes the gate output (U22-6) to be a logical "1", while the other gate output (U21-6) is a logical "0". The latch is reset when there is a loss of tape tension by a logical "0" at NAND gate input U21-5. When the latch is reset, U22-6 is a logical "0" and U21-6 is a logical "1", which deenergizes the reel motors and applies the mechanical brakes.

4-115. POWER-ON RESET. The purpose of the power-on reset circuit is to ensure that the near end-of-tape, end-of-tape, record, run, reverse, and fast latches are initially reset when the transport power is turned on. The circuit consists of an inverter which is driven by a circuit consisting of RC network resistor R9 and capacitor C2, together with transistors Q2 and Q3. The inverter input at U28-1 is initially a logical "0" when the power is first turned on, which ensures that the latches mentioned above are reset. After a short delay established by the RC time constant, the inverter becomes a logical "1", where it remains during normal operation.

4-116. TAPE SENSORS. Two sensors are used to sense the amount of tape on the reels in order to determine near end-of-tape and end-of-tape conditions. Each sensor consists of a phototransistor, as indicated on the Transport Assembly Schematic Diagram, figure 7-3. The output of each phototransistor is fed to an operational amplifier whose output is fed to one input of data stream switch U30. The supply sensor phototransistor feeds operational amplifier input U25-4 and the takeup sensor phototransistor feeds operational amplifier input U25-10. The supply sensor and the takeup sensor outputs from the operational amplifiers are fed to U30-1 and U30-10, respectively.

4-117. Data stream switch inputs U30-9 and U30-13 determine which sensor output will be passed through the switch to the data input of the three-stage counter (U27). U30-13 will be a logical "1" in the forward direction and this will allow the output from the supply sensor to be used to clock U27. U30-9 will be a logical "1" in the reverse direction and will allow the output from the takeup sensor to be used to clock U27.

4-118. Logic element U27 (figure 7-2) makes up a modified three-stage binary counter composed of D-type flip-flops. The output of U30 (pin 8) is fed to the D input of U27 (U27-4). Clock to U27 is provided by tach pulses from connector pin A1P4-7. When phase lock has been achieved, the clear input to each flip-flop is a logical "1", preventing them from clearing.

4-119. After phase lock has been achieved, the first time the slot on the reel motor flywheel allows the light to strike the phototransistor, U25-2 will be a logical "0" which places U30-8 at a logical "1". The next tach pulse sets the first flip-flop in U27 which makes U27-2 a logical "1". The second flip-flop is in the reset condition after the first tach pulse making U27-6 also a logical "1". These two logical "1's" are felt at U32-13 and U32-12, respectively, and at that time U32-11 goes to a logical "0". This logical "0" level at U32-11 is the high-to-low transition of the load pulse and is used to load a 16-stage binary counter, with a preset count into the counter every 360 degree revolution of the selected reel motor. The second tach pulse sets the second flip-flop in U27 which terminates the load pulse. The third tach pulse sets the third flip-flop, which causes the logical "0" at U27-11 commanded to U32-9, to hold a logical "1" at U32-8, which keeps the third flip-flop in the 'set' condition. Secondly, the logical "0" at U27-11, also commanded to U23-5, allows load pulses at U23-6 to control level at U23-4 to lock the NEOT and EOT flip-flops. U23-4 will be a logical "1" during the load pulse, and the ensuing "1" to "0" transition at the termination of the load pulse will provide the necessary clocking action at the NEOT and EOT flip-flops.

4-120. The load pulse (U32-11) loads the 16-stage binary counter each revolution of the reel motor. The 16-stage binary counter is made up of U26, U29, U31, and U34. The counter is continually loaded with one preset count until NEOT is reached, and then the counter is continually loaded with a different preset count until EOT is reached. Before NEOT is reached, each load pulse loads the preset count of 0000001100111000 (LSB on left). Most of the preset inputs are hard-wired, but some of the inputs are determined by the condition of the NEOT flip-flop. Before NEOT is reached, the NEOT flip-flop is in the set condition. Therefore, counter inputs U26-D, U31-C, U31-D, and U34-A are logical "1's", and input U34-B is a logical "0". This count will be loaded once each revolution of the reel motor and, in the time between load pulses, the counter will count once each tach pulse.

4-121. Each time the counter starts counting from the preset condition, the count contained in the counter will be less than the previous count cycle, because less tape was taken from the supply or takeup reel depending on direction of tape travel. Tape is taken from the reels at a constant rate (controlled by the capstan) but since the reel must rotate faster as tape pack diameter decreases, the slot on the flywheel of the reel motor takes less and less time per revolution before initiating another load pulse. Therefore, the closer to NEOT, the lower the count contained in the counter at the arrival of the load pulse. When the count fails to set the last stage of the counter (U34-D), the NEOT flip-flop will be conditioned to reset at the termination of the load pulse.

4-122. When the NEOT flip-flop is reset, preset inputs U29-C, U31-C, U31-D, and U34-A change from "1's" to "0's"; and preset input U34-B changes from "0" to "1". The new preset count now becomes 0000001000000100 (LSB on left). Once again the counter is toggled once each tach pulse and, at the end of the count cycle, if the last stage (U34-D) is set ("1"), the load pulse presets the counter and continues to count. When the final stage (U34-D) fails to set, then the termination of the load pulse will reset the EOT flip-flop. Resetting the EOT flip-flop fires the 100 millisecond one-shot multivibrator (U33). This 100 millisecond negative pulse occurring at end-of-tape (EOT reset) goes to U19-10 and is used to reset the mode latches.

4-123. 500 MILLISECOND OVERLAP ONE-SHOT. When NEOT is reached, the logical "1" at U35-6 is felt at U33-10. The logical "1" at U33-10 fires a 500 millisecond one-shot which causes U33-5 to be a logical "1" for 500 milliseconds. The logical "1" for 500 milliseconds causes Q4 to turn on, which places ground on relay coil K1, making it momentarily energize (500 milliseconds). The normally open contacts of K1 are connected to A1P4-35 and A1P4-36. These pins are connected to pins U and X of connector A1P4, respectively. When these pins are connected, a second transport can be placed into operation when the first transport reaches NEOT. Both transports will operate then until the first transport reaches EOT and shuts down. Thus, it is possible to continue recording without suffering any loss of data.

4-124. TYPE 12-405A AMPLIFIER CASE ASSEMBLY.

4-125. One 12-405A Amplifier Case is supplied with a half-inch tape width system, and two 12-405A Amplifier Cases are supplied with a one-inch tape width system. The cases are mounted either on the hinged back panel of the portable configuration, or beneath the transport in a rackmounted configuration.

4-126. Each 12-405A Amplifier Case contains a mother board which has receptacles for seven record amplifiers and seven reproduce amplifiers, in addition to connectors for optional monitor meter, voice logging, and tape lock accessories.

4-127. Figure 7-6 is a schematic diagram of the 12-405A Amplifier Case. Record amplifier output connections are made with coaxial cables from the mother board to head connectors. Twisted pair leads connect the reproduce preamplifier outputs to the reproduce amplifier inputs on the mother board.

4-128. LED FOOTAGE COUNTER AND SHUTTLE OPERATION.

4-129. Power supplied from the transport is +18 V which is regulated on the LED Footage Counter board to +12 V and +5 V. This board has a battery (+4.5 V) for the maintenance of memory in the case of power failure or when the system is switched off.

4-130. Figure 7-7 is the schematic diagram of the LED Footage Counter. The tachometer signal is buffered through U5-3, 4 to jumper terminal E1, or on to buffer U5-1, 2 and rate multipliers U2 and U3 for metric adaptation, and from U3-6 to jumper terminal E3. The terminals E2 and E4 are common and connect to prescaling by U7, U8 and half of U11. The signal then proceeds through open collector buffer U5-9, 8 to counter IC U16-36. The SET terminal, U16-2, is not used and is tied high through one of the resitors (4.7K ohm) of U28.

4-131. The counter can be reset to 0000.0 by grounding edge connector pin 20 from the Remote station or by grounding pin 16 of J2 on the display connector on the Counter board. In either case, pin U4-11 is caused to go to a logic high state. Through buffers U5-11, 10 and U5-5, 6 the CLR input of the counter U16-20 is raised to +12 V, resetting the counter to zero.

4-132. Edge connector pins R and S are redundant direction inputs from the Capstan and Reel Servo card. Whichever of the two is in the high state will - through inverters U9-3, 4 or U9-5, 6 and RC low pass combinations R3C3 or R4C4 - lower one of the inputs of latch U4-1, 2, 5, or 6 raising the corresponding latch output to a logic high. Latch output U4-3 is buffered through U4-8, 9, 10 and U5-13, 12 to UP/DOWN control input pin U16-40. When edge connector pin R is low, the system will count UP.

4-133. The six digit count is multiplexed in binary form through ABCD terminals 11, 12, 13, 14 of U16 and for seven segment display through terminals U16-24, 25, 26, 27, 28, 29 as time slot or Digit D1, D2, D3, D4, D5, D6. Binary value ABCD is buffered through U17-1, 2; 12, 13; 3, 4 and 6, 5 to memory IC U23-15, 13, 11, and 9. Digit multiplex is also buffered through U17-8, 9 and U22-4, 3, 2, 1, 21, 5 as well as through the open collector buffer U27 to the display jack J2. Under normal operation the count is written into memory IC U23 continually. For this purpose the Chip Enable 2 pin U23-17 is at logic high while the read/write pin (R/W) U23-20 is at a logic low.

4-134. During power failure, the power ON/OFF circuitry (R23 through R30, CR3 through CR8, U6) causes Chip Enable pin U23-17 to go low as soon as either the +5 V supply goes to +4.5 V or the +12 V supply reaches +8 V. This condition will discontinue the update of count state into U23 before it becomes unreliable. U23 memorizes the last reliable count supplied to it by U16 long after power has been removed because of the +4.5 V battery (B1), which supplies approximately 10 microamperes through CR2, while CR1 blocks battery power from going to waste in the remaining circuitry.

NOTE

When in the SHUTTLE mode, and power is lost to the 4020A, shuttle memory is not maintained.

4-135. When power is restored to the circuit, the CMOS and TTL ICs will come up randomly. To prevent errors, a reset condition is maintained on U10 and the second half of U11. As the supply voltages increase, the voltage drop across diode clamp CR4, CR5, CR6 settles at about 2 V. This voltage is used as reference on comparator inputs U6-4, 7, and 10. From the respective voltage dividers come linearly increasing fractions of the +5 V and +12 V supply voltages to terminals U6-5 and U6-11. Only when both voltages have exceeded minimum operating levels will both comparator outputs be at their high states and allow the third comparator to be tripped, causing output pin U6-1 to go from high to low, allowing U10 to begin counting. U11, just out of reset state, will receive the Carry output of U10 and change state, i.e., U11-13 will then go to a logic high state. Since U18-5 and 6 are high, the read/write pin of U23-30 goes low into the Write mode. Inverters U9-11, 10 and U19-13, 12 have their open collector output pins ORed. Pin 12 will initially stay low since pin U6-1 is high before +4.5 V and +8 V have been reached. After these levels have been exceeded, pin U6-1 will go low, allowing U9-12 and 10 to go to +12 V as well as pin U16-31, the load counter function. With memory U23 in Read mode and the Load counter pin of U16 high, previously stored information is loaded into the counter. This cycle is terminated as soon as U11-11 receives the Carry pulse from U10-7. At this time, U11-13 goes high and causes U9-12 to go low, ending the load sequence. The counter is now in its normal counting mode and will count up or down as required by the state of direction inputs R and S.

4-136. U11-12, the $\overline{Q}$ output, is used to reset latch U1-4, 5, 6, 8, 9, 10, such that the gates U1-1, 2, 3 and U1-11, 12, 13 do not transmit information presented to their input pins 1 and 12 from the counter IC, when it detects that either the counter is at the zero state or that the count is presently equal to the number loaded into its comparator register. The corresponding pins are U16-39 (Zero) and U16-23 (EQL). The latch portion of U1 has a resistive divider to combine the positive feedback path from pin 8 with the just described reset input from U11-12. Gate output pins U1-3 and 11 activate the run and reverse latches on the Control Logic Board. The U1 latch is also reset to zero by Reset operation. This is necessary so that the Forward run is not intercepted by the detection of an EQL when the present count is equal to a previously set target number. The latch is permanently forced into its reset state when the NORMAL-SHUTTLE switch is in the NORMAL position.

4-137. When this switch is in the SHUTTLE position, then besides being reset in the three manners mentioned, latch U1 can also be set. U1 is set when loading a target number into the comparator register of the counter IC. Lowering the normally high pin J2-15 or edge pin X puts a logic low spike through C11 on U24-10. The latch portion of U24 is set and pin 8 is high while pin 3 is low. While

previously gate U32-1, 2, 3 has passed digit strobe pulses from U16-24 via buffer U22-8, 9 to latch U32-12 and resetting pin U32-8 low, the next digit strobe pulse will pass through gate U32-4, 5, 6. Pin 6 will momentarily go low and set latch U32 with pin 8 going high, and beginning the register load cycle. When the strobe pulse ends, U32-6 returns high. Pin U24-4 is high because U32-8 is set high. Now pin U24-5 is made high by U32-6 and the output pin U24-6 goes low resetting latch U24 by the low spike into its pin 1, which returns the ability to transmit to U32-1, 2, 3. The next digit strobe pulse will cause latch U32 to be reset and pin 8 to go low. The register load cycle will last for the loading of exactly six digits into the comparator register in their binary format (ABCD). This is due to the direct pin to pin connection of U16-11, 12, 13, 14 to U16-35, 34, 33, 32. Immediately, an EQL output is generated by the comparator which is transmitted to the Control Logic board by the gate portion of U1. Latch U1 was set when pin U32-6 went low during the target number loading operation. This was caused by activating REV SET (grounding J2-15 or edge pin X). Usually this is done while the transport is running forward.

4-138. The counter, which is receiving direction information from the Capstan and Reel Servo card, consistent with its present direction, will count UP if the motor is slowing down in order to reverse, or count DOWN if the motor has already reversed direction. In this way the count is accurately related to the tape position, except for minor error caused by tape slippage during slow-down and acceleration. This error may amount to one inch in every 6 to 10 shuttle cycles. To make footage or metric information available at the Remote station, both the digit strobe pulses and the segment information are loaded parallel into a 16 bit shift register. Since only 13 bits are required, the last three are loaded with zero by tying the corresponding parallel inputs to ground. The shift register uses U21 and U26 in series. Serial shift pulses at a rate 16 times that of the digit strobe pulse frequency are generated by a phase locked loop U19 with U12 dividing the shift frequency by 16 and supplying this result for comparison back to U19-3. While U19-14 receives the combined digit strobe pulses from OR gate U25-1, and frame sync, pulses are derived from U25-13 to line driver U20-6. The Parallel/Shift control inputs of U21 and U26, pins 9, are controlled by U25-13, inverter U18-1, 2, 3 (pin 1 high), and buffer U31-5, 6. Parallel loading occurs during the digit strobe intervals, while shifting occurs during the digit strobes. Shift pulses appear at the output of VCO U19-4 and are buffered to U21 and U26 pins 10 as well as for use in the Remote station, to line driver U13-15. The serially shifted output from U21-3 goes to line driver U13-6. Line driver outputs U13-7 and 9 and U20-7 go to edge pins T, U, and Z as DATA, CLOCK, and frame sync (FS). U29 is the +12 Volt Regulator IC.

4-139. Both CMOS and TTL logic ICs are used on the LED Footage Counter Board so attention has been given to signal adaptation. In some cases by choice of IC or by having a buffer doing the adaptation by using TTL open collector ICs for going from TTL to CMOS, or by passive adaptation networks or voltage dividers, as in the case of R16, R18, R17, and R19.

4-140. AMPLIFIER MOTHER BOARD.

4-141. GENERAL. An amplifier mother board is part of each 12-405A Amplifier Case. Each mother board has receptacles for seven record amplifiers and seven reproduce amplifiers, in addition to connectors for optional monitor meter, plug-in FM calibrator, voice logging, and tape lock accessories. Circuits are also provided for speed switching, squelch, and record control lines. With the exception of the front panel signal input and output connections, all internal system connections are complete when the plug-in units are installed in their respective connector positions. All the internal connections to the mother board are shown in figure 7-6. Figure 7-9 is the schematic for the mother board.

4-142. RECORD AND REPRODUCE AMPLIFIER CONNECTORS. The connectors for the record and reproduce amplifiers are designated J1A through J7A and J1B through J7B, respectively. The connectors are wired so that all the speed control, dc power, bias, record enable, and squelch lines are wired to the same pins of each connector. The bias line may be jumpered at E92 and E93 should the board be used for a 14-channel record capability. The FM and direct record/reproduce amplifiers are designed to utilize the same pins for all common requirements, thus permitting them to be mixed in system operation. Reference to the FM record amplifier schematic will show that pin L (Bias) is not used in the FM record amplifier and, likewise, pin K (squelch) is not used in the direct reproduce amplifier. Connections to the record head connectors and to the reproduce preamplifier outputs are hard-wired from the "E" numbers shown on the schematic. Operating voltages for the record/reproduce electronics are from the "E" numbered connectors and they too are wired in parallel to each of the connectors. Terminals E134 through E161 are record amplifier input connections (in parallel with the front panel connectors) which are cabled to rear panel connectors when the system is rackmounted. Similarly, terminals E120 through E133 are provided to allow reproduce amplifier rear output connections.

4-143. MONITOR METER CONNECTOR. The connector designation for the optional monitor meter is J9. It is located in the first position of the mother board. The monitor meter receives its signal inputs from the record/reproduce amplifiers on E16 through E42, excluding the odd numbers which are the corresponding shield grounds. Operating voltages for the monitor meter appear on pins 3, D, and 5 of J9. The RECORD TEST line leaves the monitor meter on J9-1 and is a logical "0" when the RCD TEST switch is in the ON position.

4-144. TAPE LOCK UNIT CONNECTOR. The connector designation for the optional tape lock accessory is J8. This connector is adjacent to the monitor meter location. The servo reference frequency from the control logic board in the transport is cabled to terminal 19 on connector J8. The reproduced reference frequency leaves the tape lock board at terminal 1, where it is cabled to the servo circuit board in the transport. Speed control lines to select filtering networks are connected to terminals 11 through 17 of J8. Logic levels from the transport indicating RUN, RECORD, and PHASE LOCK enter the tape lock unit at terminals 8, 9, and 10, respectively. A TAPE MODE indication is routed to the transport servo board from terminal K of J8, via E47.

4-145. VOICE LOGGING UNIT CONNECTOR. The connector designation for the optional voice logging unit is J10. This connector is between the tape lock connector and the first record amplifier connector. The connections to the record head are on pins A and 2 via E52 and E53, and from the reproduce preamplifiers on pins F and H via E54 and E55. The speaker connections are on pins V/18 and W via E58 and E59. Speed control lines for 15/16 ips, 1-7/8 ips, and 3-3/4 ips are on pins M, N, and P, respectively. The bias frequency is always present on pin 10 via E56, thus the voice logging unit may be energized in any mode of operation.

4-146. SPEED CONTROL LINES. The speed control lines electrically activate the appropriate record/reproduce amplifier circuits matching them to the selected tape speed. The TAPE SPEED SELECTOR switch on the control panel provides a logical "0" signal to one of the terminals E8 through E14, depending on the selected speed. As an example, say for 15 inches per second, a ground signal on E12 will cause relay K3 to energize and the normally open contacts of K3A1 will apply +5 volts on pins 15/S of all the signal amplifier connectors. The other speed control lines are wired similar to the 15 ips line except for the 3-3/4 ips line. The 3-3/4 ips line is only connected to pin 13 of record/reproduce amplifier connectors. The seven speed control relays are K1-K7 and each has a diode placed across the relay coil. The diodes prevent any generated back emf from damaging the amplifier electronics circuits.

4-147. SQUELCH. The squelch line inhibits the FM reproduce amplifier outputs when the transport is not in phase lock and in a run mode. This signal from the transport control logic is a logical "1" signal when it is active and is routed to terminal E7 on the mother board. This signal saturates Q1, thus energizing relay K13 and closing the normally open contacts which apply a +5 volt level to pin K of all the record/reproduce amplifier connectors.

4-148. RECORD ENABLE. The record enable signal energizes the record amplifiers when the transport is placed in the record mode and is in phase lock or when the RCD TEST switch mounted on the monitor meter is in the ON position. This signal is a logical "0" when it is active and is routed to terminal E6 on the mother board, thus energizing relay K9 and closing the normally open contacts which apply a ground signal to pin J of all the record/reproduce amplifier connectors. Resistor R2 holds the record enable line high when it is not active.

4-149. TEST MODE. (See figure 7-9.) The Test Mode is included in the mother board. This board contains five 2-pole, 5-volt relays (K8, K10, K11, K12, and K14), which are activated by setting the RCD TEST switch (located on the Monitor Meter panel) to ON. (Setting the RCD TEST switch ON permits FM record and FM reproduce amplifiers to be interconnected - bypassing the heads; this permits deviation sensitivity and center frequency adjustments and record/reproduce matching without moving tape.) Relay K11 disables the squelch: one pair of contacts grounds the base of squelch transistor Q1, a second pair of contacts connects +15 volts to all circuit card pins P (disables squelch when universal FM Reproduce Amplifier circuit cards are used). Relays K8, K10, K12, and K14 (when activated) connect all record amplifier circuit card pins 8 (record output) to all reproduce amplifier circuit card pins 8 (reproduce input). Note that all pins 8 are functional only on FM circuit cards. The record output (pin 8) is an alternate head driver output and the reproduce output (pin 8) is inserted after the FM first stage amplifier (before the first FM limiter).

4-150. REPRODUCE PREAMPLIFIERS.

4-151. GENERAL. The reproduce preamplifier circuit boards plug into the preamplifier housing assembly. This assembly is located on the rear of the transport between the upper and lower reel motors. There are two circuit boards in 1/2-inch tape width systems, and four circuit boards in 1-inch tape width systems. Each circuit board contains four independent preamplifier circuits for a maximum of 16 channels. The ±15 volt power distribution is shown schematically in figure 7-5. The signal input wiring from the reproduce head connectors and the output connection to the mother board are shown in figure 7-6.

4-152. PREAMPLIFIER CIRCUIT DESCRIPTION. Figure 7-8 is a schematic diagram of the reproduce preamplifier circuit board showing the four independent, but identical, circuits. A simplified schematic of one of the circuits is shown in figure 4-29.

4-153. PREAMPLIFIER VOLTAGE REGULATOR. Figure 7-10 is a schematic diagram of the preamplifier voltage regulator circuit board.

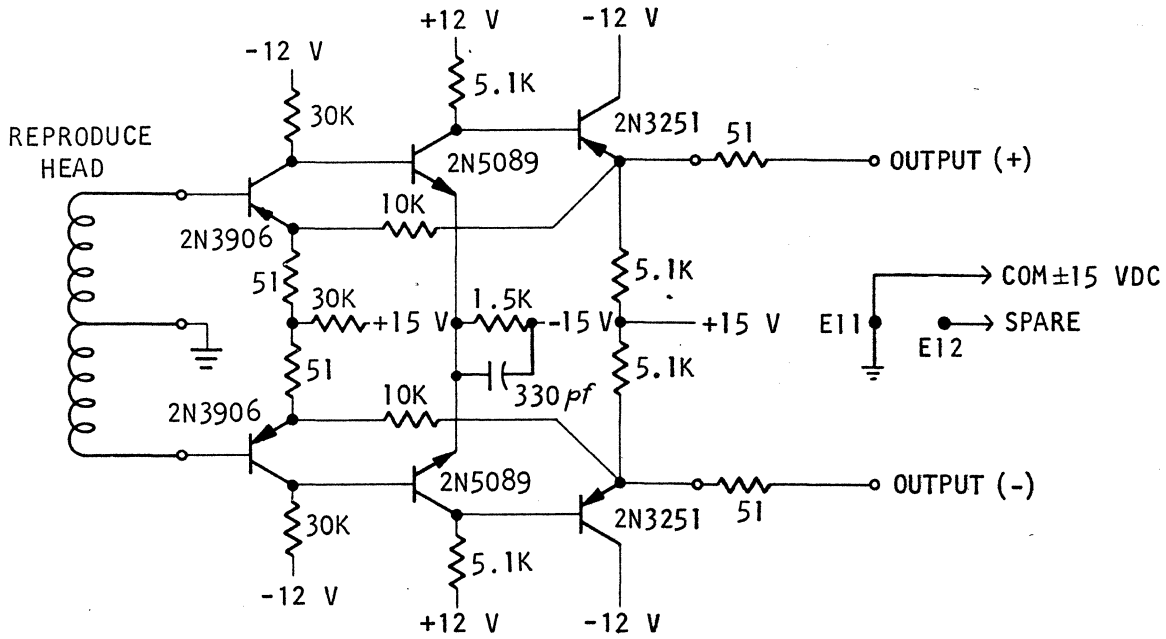


Figure 4-29. Simplified Schematic, Reproduce Preamplifier

SECTION V

CALIBRATION AND MAINTENANCE

5-1. GENERAL.

5-2. Maintenance on the 12-401D Tape Transport should be performed by qualified technicians familiar with this type of equipment. Maintenance includes preventive procedures, calibration procedures, and troubleshooting techniques necessary to correct faults and keep the transport operating at maximum performance.

5-3. Access to the transport components behind the baseplate may be gained by removing the two screws at the top of the system and lowering the hinged rear section. (See figure 5-1.)

5-4. Front transport components are shown in figure 5-2 and those on the rear baseplate are illustrated in figure 5-3.

5-5. PREVENTIVE MAINTENANCE.

5-6. The scheduling of preventive maintenance is related to the operating environment and to the use to which the equipment is subjected. Table 5-1 briefly describes the scheduling of and the procedures for preventive maintenance of the transport. The preventive maintenance schedule given in table 5-1 is based on the equipment being used under laboratory conditions, 8 hours per day. Under more adverse environmental conditions, or longer periods of use, it may be necessary to increase the frequency of the preventive maintenance procedures. When performing the preventive maintenance procedures, replace, repair, or adjust, as applicable, any assembly or component found defective or inoperative.

5-7. CALIBRATION PROCEDURES.

5-8. The following procedures include all mechanical and electrical adjustments necessary to ensure optimum transport operation. It should be noted that these adjustments are not required under normal operating conditions, except as indicated in the preventive maintenance procedures or in the event of component failure and subsequent parts replacement.

5-9. Table 5-2 lists the test instruments and equipment necessary to properly adjust and calibrate the 12-401D Tape Transport.

5-10. TENSION SENSORS. Static tension is established by torsion springs in the tension sensor assemblies. (The spring for a 1/2-inch tape width system is Bell & Howell part number 379538, and Bell & Howell part number 379632 for a 1-inch tape width system.) The tension sensor assembly is illustrated in figure 6-3.

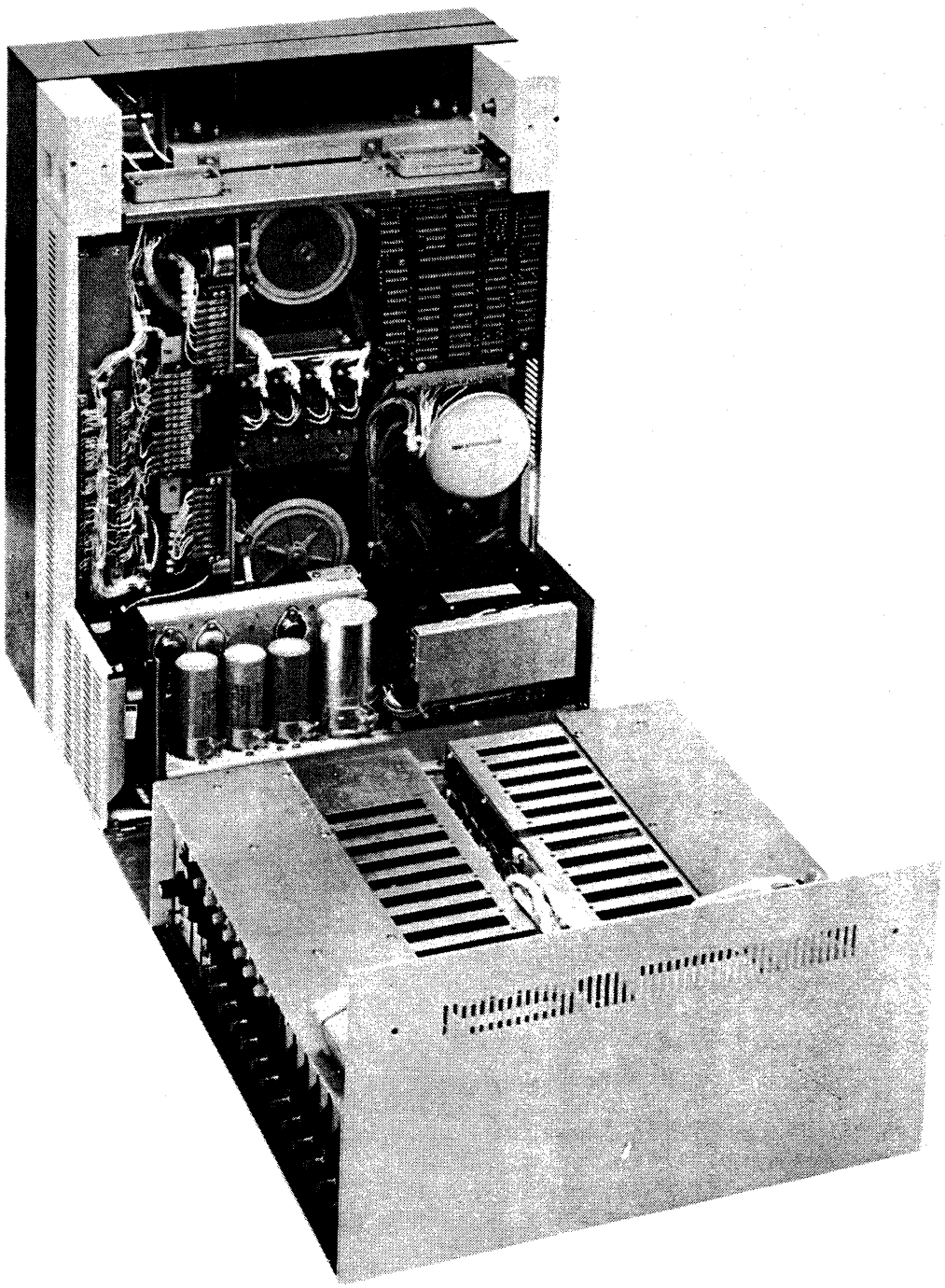


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Figure 5-1. Transport Access

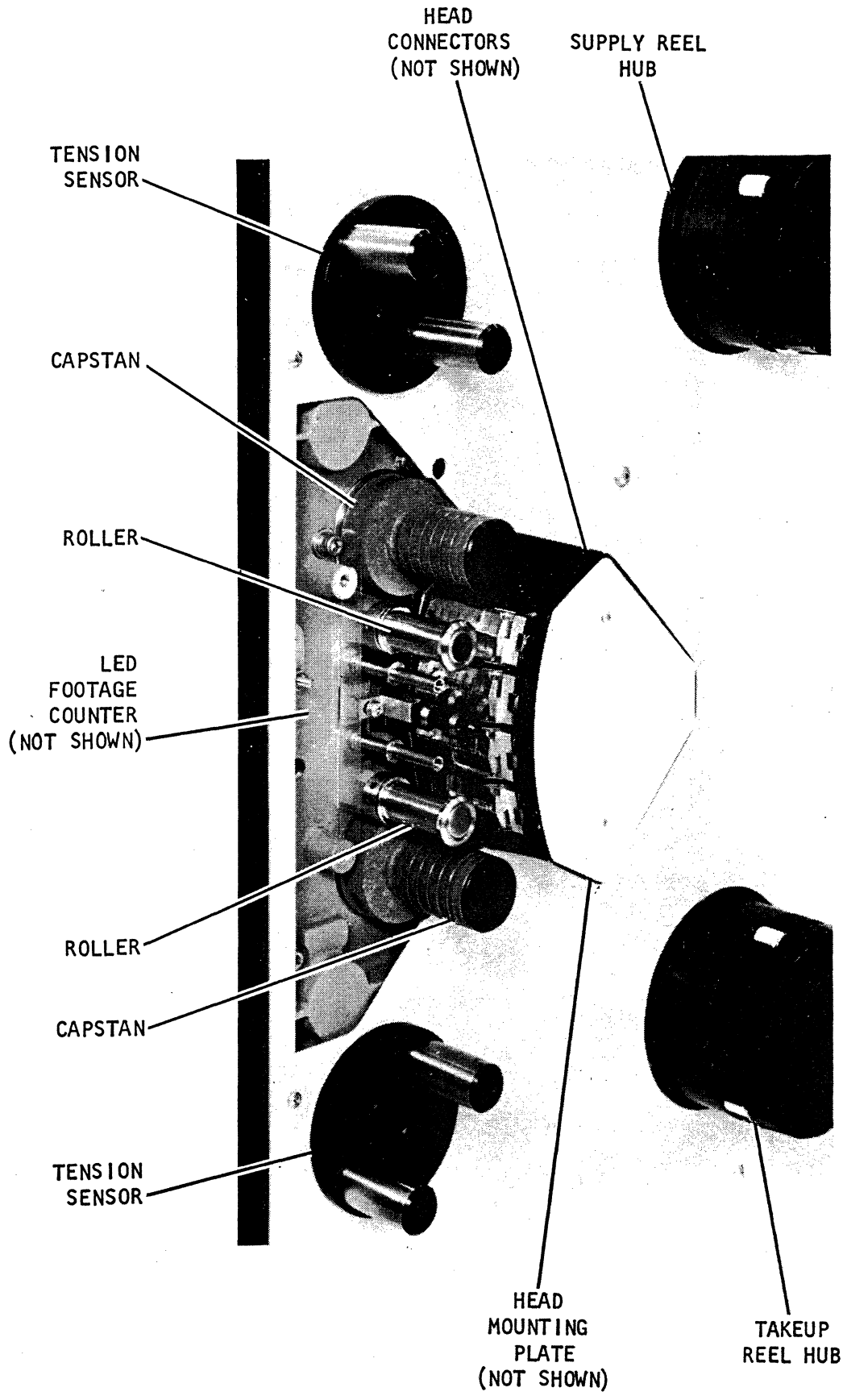
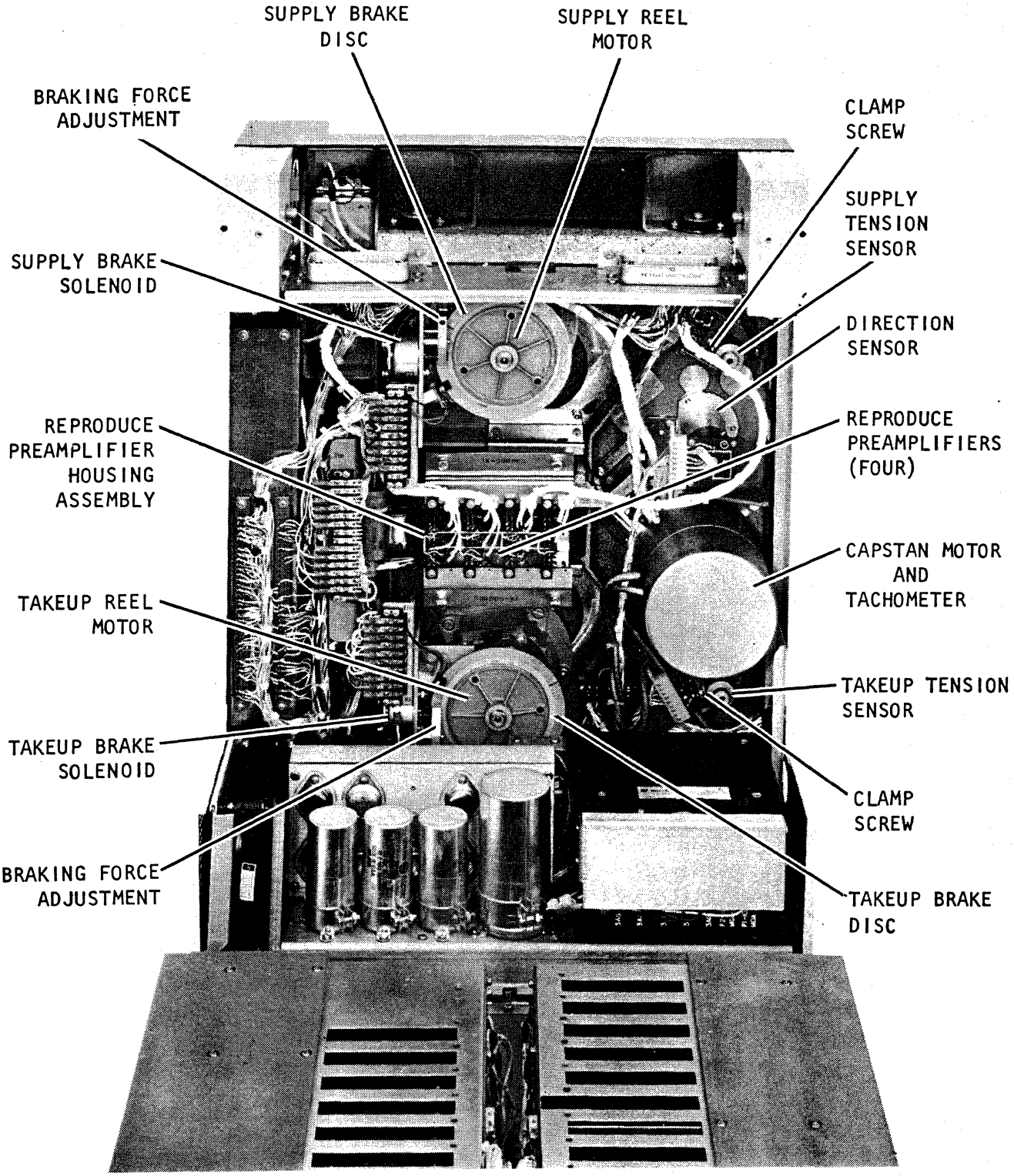


Figure 5-2. Front View, Tape Transport



3608-3

Figure 5-3. Rear View, Tape Transport

ITEM	TYPE OF PREVENTIVE MAINTENANCE	SCHEDULE	PROCEDURE
			CAUTION The CAPSTANS are urethane coated, and therefore very susceptible to becoming tacky by the action of most chemicals. The capstans should be cleaned with a solution of soft soap and warm water.
1	Clean the magnetic head stacks and tape handling surfaces.	Daily (Sooner, if needed.)	Clean all surfaces contacted by the tape using a cotton swab moistened, not saturated, with DuPont Freon TF. Be careful not to scratch or mar the surface of the components, and be sure to remove all excess fluid after cleaning. CAUTION Only DuPont Freon TF should be used to clean the tape handling components (EXCEPT for the CAPSTAN). It is nontoxic and nonflammable. DO NOT USE carbon tetrachloride, alcohol, trichloroethylene, or any cleaning agent which might be detrimental to the tape handling surfaces. NOTE Freon TF, a DuPont product, is available from any DuPont Freon solvent sales agent.

Table 5-1. Preventive Maintenance Procedures and Scheduling (Sheet 1 of 4)

ITEM	TYPE OF PREVENTIVE MAINTENANCE	SCHEDULE	PROCEDURE
2	Demagnetize the magnetic head stacks and tape handling components.	As determined necessary by performance checks.	One symptom of magnetized heads or tape handling components is excessive second harmonic distortion and/or noise present in data reproduced from the tape which cannot be attributed to the electronics. The head stacks and components can be demagnetized with a portable hand degausser as follows: Turn on the degausser and move it in a circular motion around the heads and components for about 15 seconds. Continue the circular motion and slowly pull the degausser away from the transport. Do not turn the degausser off until it is at least three feet away. Better results can be obtained when demagnetizing the heads by removing the entire head assembly from the transport before exposing it to the field of the degausser. Never turn a degausser off while some component is in its field or the inductive surge will set up a field of single polarity and remagnetize the component. Procedures for removing the head assembly are given in paragraph 5-30.
3	Clean the air filter.	Monthly	The air intake filter must be kept clean in order to prevent overheating of the power supply and transport components. To clean the filter, lower the back panel of the transport and slide out the filter assembly (P/N 519269). Flush out accumulated dust by running a stream of water through the filter from the inside out, opposite the direction of air flow. Dry the filter with low pressure air and replace the filter in the system.

Table 5-1. Preventive Maintenance Procedures and Scheduling (Sheet 2 of 4)

ITEM	TYPE OF PREVENTIVE MAINTENANCE	SCHEDULE	PROCEDURE
4	Check the capstan belt.	Monthly	Remove the capstan belt cover and inspect the capstan belt for any signs of bad fit, creasing, cracking, splitting, or fraying. If necessary, replace the belt by following the procedures in paragraph 5-15. The belt should be cleaned with Freon TF.
5	Check the electrical adjustments of the capstan and reel servo systems.	Monthly	Follow the procedures given in paragraphs 5-23 and 5-24.
6	Lubrication.	Monthly (or as determined by performance checks)	Remove the damping roller and clean it and its shaft with Freon TF. Apply oil, part number 84309-0003, sparingly to the roller shaft. Reinstall the roller and adjust its position by following the procedures in paragraph 5-21. All other components are lubricated and sealed at the factory and further lubrication is not required.
7	Remove dust and other foreign particles from the transport.	3 months	Lower the rear section and clean out the transport assembly with the aid of low pressure air.
8	Visually check all electrical and mechanical components and connections for signs of deterioration or defects.	3 months	Lower the rear section. Replace or repair any components or connections found defective.
9	Check the static tension of the tape tension sensor assemblies.	3 months	Static tension should be 6 $\pm$1 oz in a 1/2-inch tape width system and 8 $\pm$1 oz in a 1-inch tape width system. Measurement

Table 5-1. Preventive Maintenance Procedures and Scheduling (Sheet 3 of 4)

ITEM	TYPE OF PREVENTIVE MAINTENANCE	SCHEDULE	PROCEDURE
			techniques and adjustment procedures are described in paragraph 5-14.
10	Check the condition of the mechanical brakes.	3 months	Replace the disc brake pads if excessively worn. Check the braking force and make any needed adjustments by following the procedures in paragraphs 5-19 and 5-20.

Table 5-1. Preventive Maintenance Procedures and Scheduling (Sheet 4 of 4)

EQUIPMENT	USE
Oscilloscope: Tektronix 545B/1A1, or equivalent	Waveform observation during calibration and troubleshooting.
Volt-Ohm-Milliammeter: Triplett 630, or equivalent	Presetting controls and general troubleshooting.
Flutter Meter: Data Measurements 8300, or equivalent	Adjustment of damping roller position.
Demagnetizer: Amplifier Corporation of America 200C, or equivalent	Degaussing of magnetic heads and transport rollers, guides, etc.
1 pound Spring Scale	Adjustment of tension sensors.
5 pound Spring Scale	Adjustment of mechanical brakes.
10 pound Spring Scale	Adjustment of capstan belt tension.
DuPont Freon TF	Cleaning of heads, rollers, guides, etc.

Table 5-2. Test Instruments and Equipment for Maintenance

5-11. To remove the torsion spring from the tension sensor assembly, use the following procedure:

a. Remove cover plate (figure 6-3, item 26).

b. Relieve torsion spring tension by loosening clamp at the side of the knurled adjustment knob.

c. Remove roller support plate assembly by removing four Allen screws.

d. Remove dowel pin, which secures spring to the upper, rotating portion of the assembly.

e. Loosen two Allen setscrews which secure the fixed end of spring.

f. Withdraw torsion spring from upper end of assembly.

5-12. Replace the torsion spring as follows:

a. Install spring in tension sensor assembly so that spring wire ends are in rotating portion.

b. Install dowel pin through end of torsion spring in rotating portion of assembly. Ensure that all spring wire loops are secured by the pin.

c. Tighten two Allen setscrews at fixed end of spring. The ends of the two Allen setscrews should butt together, securing all wire loops of the spring.

d. Install roller support plate assembly.

e. Install cover plate.

f. Adjust sensor by following procedures in paragraphs 5-13 and 5-14.

5-13. Adjustment of the torsion springs is required following parts replacement. The springs are adjusted to provide 6 oz $\pm$1 of static tape tension for 1/2-inch tape width system or 8 oz $\pm$1 of tension for a 1-inch tape width system.

5-14. Adjust tension sensor assemblies as follows:

a. Remove capstan belt cover.

b. Attach a length of string to the upper guide roller or lower tape guide assembly and thread string through the tension sensor rollers, as shown in figure 5-4.

c. Attach a 1 pound spring scale to the free end of string and pull scale until rollers are positioned horizontally with respect to one another. (When measuring the takeup tension, position the scale as vertically as possible without allowing string to contact the footage counter.)

d. Loosen clamp at the side of the knurled adjustment knob and turn knob until scale reads proper tension as identified in paragraph 5-13. Tighten clamp screw.

5-15. CAPSTAN DRIVE BELT. The capstan belt must be clean and free from wear, deterioration, and damage before the belt tension can be adjusted. To replace and/or adjust the belt, perform the following steps:

a. Remove head assembly (see paragraph 5-30).

b. Remove capstan belt cover.

c. Loosen three screws (figure 5-5, items 1, 2, and 3) securing upper capstan and direction sensor assembly to the baseplate.

d. If required, take off old capstan belt and replace it with a new one.

e. Rotate capstan manually and observe position of belt. The belt should ride closest to inside edge of pulley. Reverse belt, if necessary, to improve positioning.

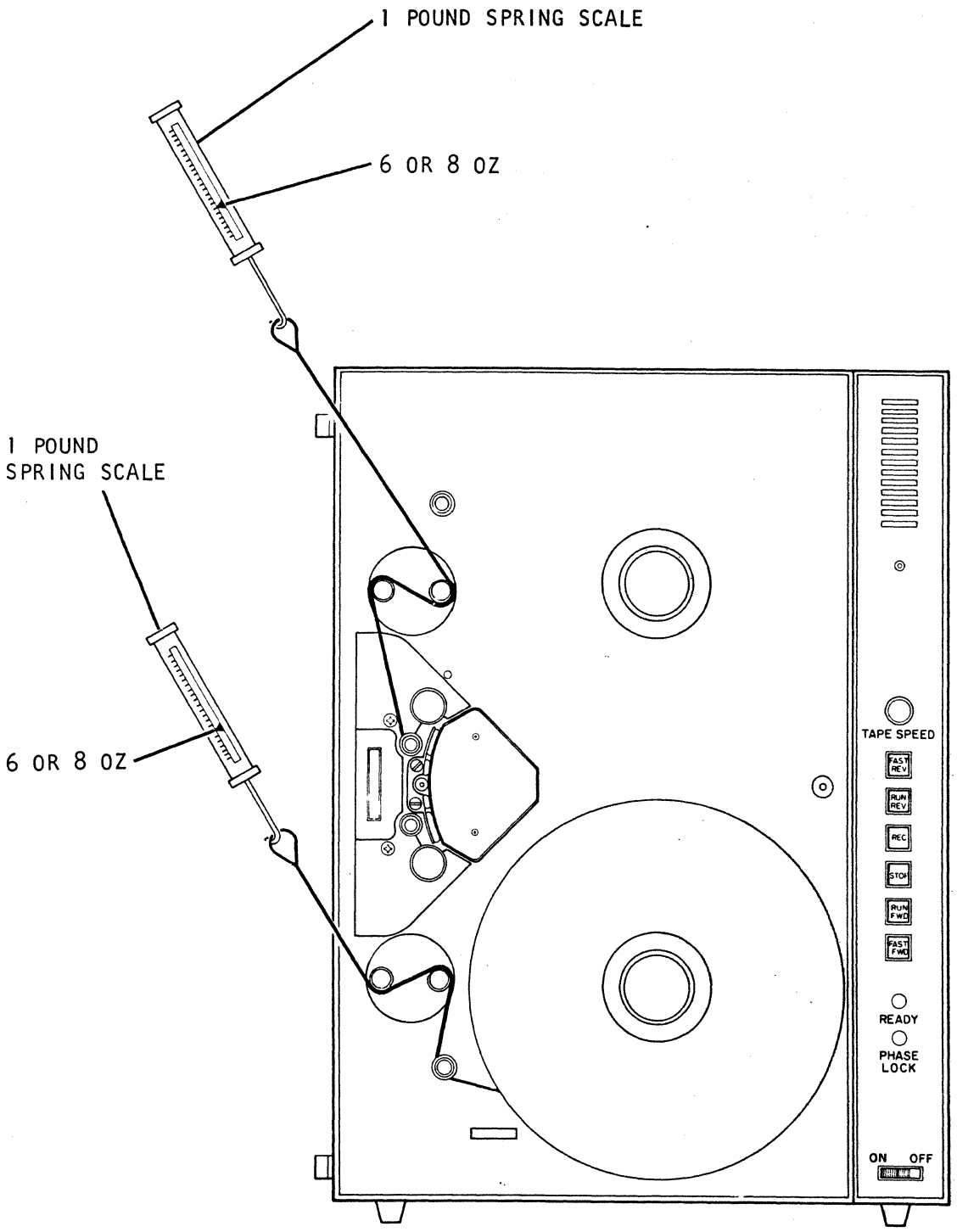
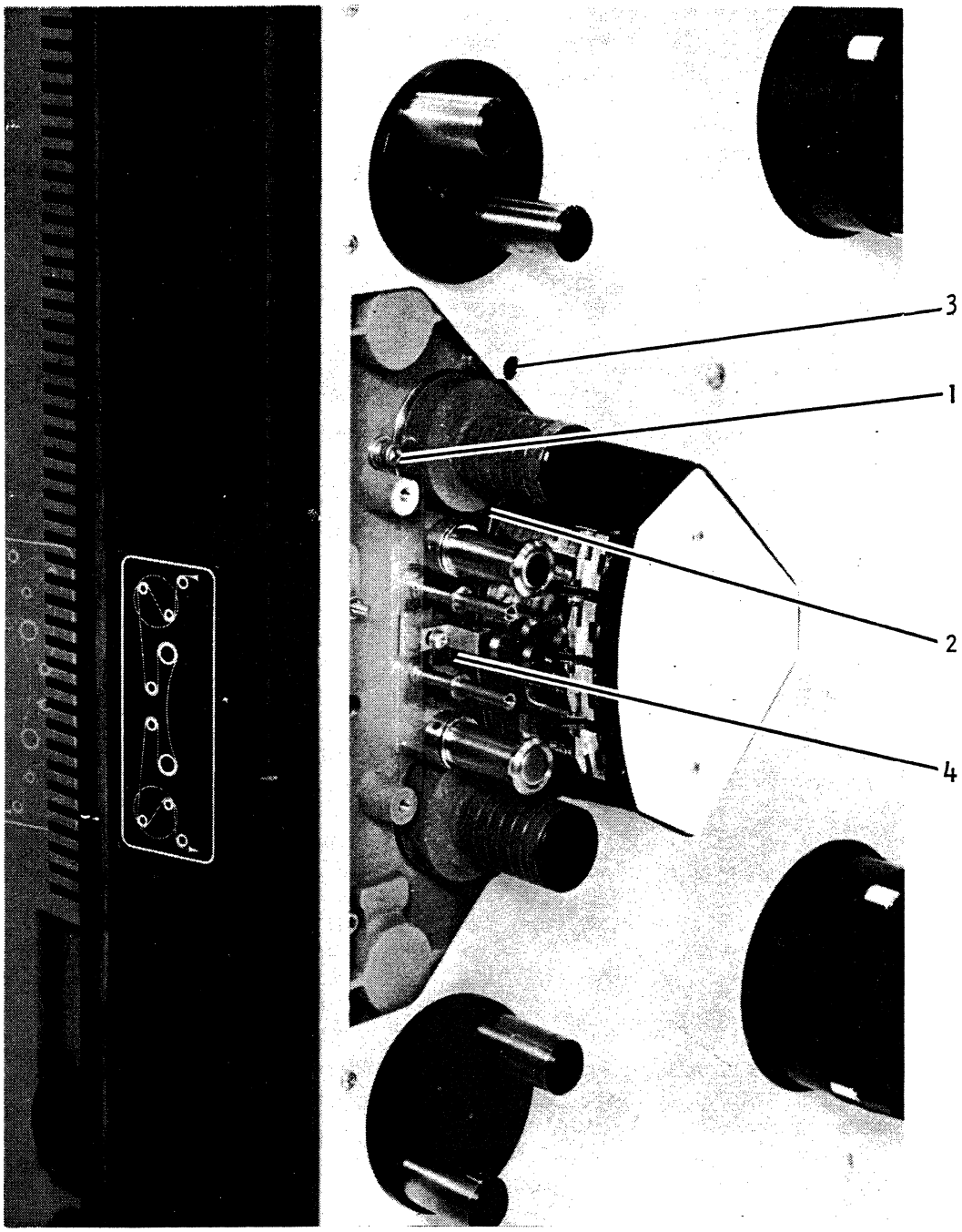


Figure 5-4. Tension Sensor Mechanical Adjustment



3923-3

Figure 5-5. Belt and Damping Roller Adjustments

f. Secure one end of a length of heavy cord around footage counter groove in the upper capstan assembly. Attach a 10 pound spring scale to other end of cord.

g. Apply 7 pounds of force in a vertical direction outward from belt loop and tighten screw, item 1, then item 2, and then item 3.

h. Replace capstan belt cover and head assembly.

5-16. REEL HUB CLAMP. The reel hub clamp is aligned at the factory and must be changed when a new reel motor is installed. The clamp is a brass slit ring mounted on the reel motor shaft. To replace the reel hub clamp on the new motor, perform the following steps:

a. Remove old motor from transport. Three mounting screws accessible from the back of the transport plate hold the reel motor in place.

b. Remove reel hub assembly from reel hub clamp. The reel hub assembly is secured to reel hub clamp by three socket head screws. For access to these screws, remove snap-on plug from hub assembly and rotate hub knob until screws are visible through base of hub.

NOTE

If only the reel hub assemblies are being changed, it is not necessary to realign the reel hub clamps.

c. Loosen two screws from reel hub clamp and install clamp on new motor.

d. Set top of clamp to be 0.894 inch from front mounting surface of motor adapter plate. Retighten two screws in clamp by alternately applying gradual degrees of torque to each screw until they are tight.

e. Reinstall motor in transport.

f. Remount reel hub assembly on reel hub clamp.

CAUTION

In order to retain motor shaft perpendicularity, do not remove the adapter plate from the reel motor casting.

5-17. DIRECTION SENSOR. The direction sensor is shown in figure 5-6. The lamp is held in the direction sensor cavity by the lamp holder. To remove the lamp, first loosen nut (item 1) and move the lamp holder (item 2) to gain access to the lamp.

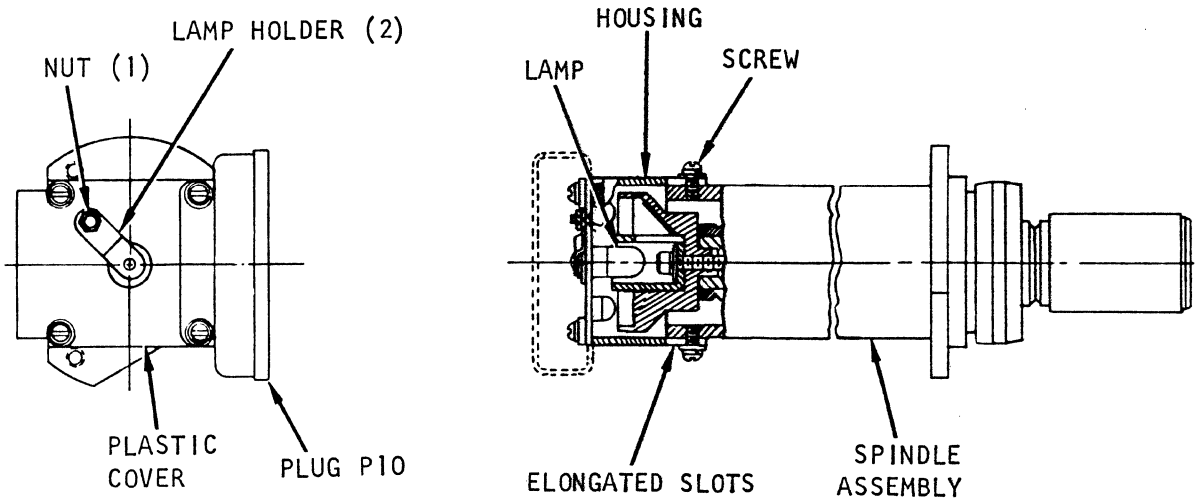


Figure 5-6. Direction Sensor

5-18. Three mounting screws in the housing hold the cover in position. To adjust position, shut off power, loosen the three mounting screws, push housing until it bottoms onto the capstan guide spindle assembly, and then move it back approximately 0.010 inch. Retighten the three mounting screws.

5-19. BRAKES. The reel motor assemblies are equipped with mechanical disc brakes which are applied when the transport is stopped or the power is off. Each brake disc should be positioned on the motor shaft so that it is equidistant from the two brake pads, as shown in figure 5-7.

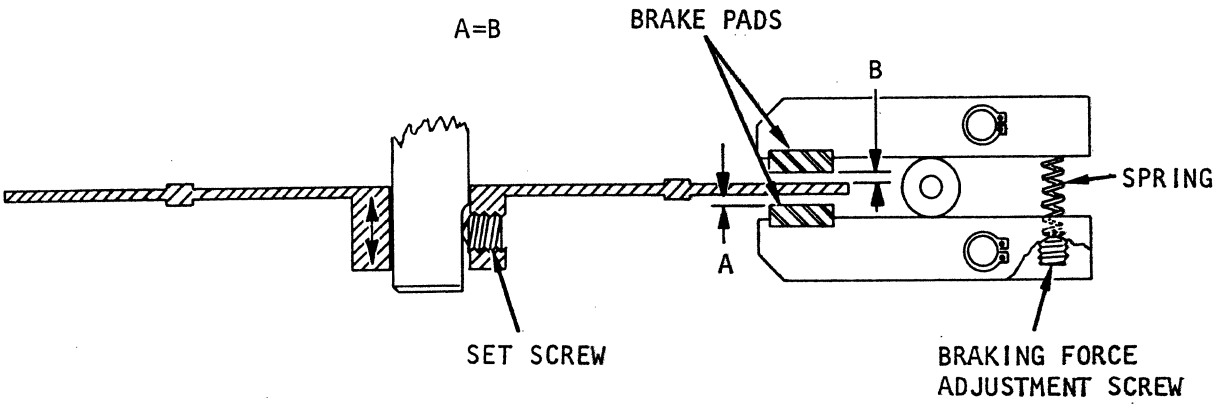


Figure 5-7. Brake Adjustments

5-20. The braking force must be set so that the mechanical brakes will stop the tape safely in case of a power failure, when the normal dynamic braking is ineffective. The following procedure is suggested:

a. Wind approximately 10 feet of tape on an empty reel.

b. Install reel so that as tape is pulled from it, reel will rotate in direction of maximum braking force. The upper reel is therefore tested in the counterclockwise direction and the lower reel in the clockwise direction.

c. Attach a 5 pound spring scale to the free end of tape and pull scale slowly with a constant force while unwinding tape from reel. The scale reading should be approximately 3 pounds for a 1-inch tape width system and 2-1/2 pounds for a 1/2-inch tape width system.

d. The braking force may be adjusted with the Allen head screw illustrated in figures 5-3 and 5-7.

5-21. DAMPING ROLLER. The position of the damping roller need not be adjusted unless it has been disturbed and/or the transport flutter or dynamic skew is out of specification at 60 ips. If adjustment is required, proceed as follows:

a. Remove capstan belt cover.

b. Loosen the Allen screw at side of damping roller cap and adjust the second Allen screw on the end of the cap, so the roller rotates freely on the shaft with minimum end play. Tighten the side screw.

c. Loosen roller assembly mounting screw, (figure 5-5, item 4).

d. Set up test equipment to measure flutter and dynamic skew at 60 ips (10 kHz flutter bandwidth).

e. Adjust damping roller position for minimum flutter and dynamic skew.

f. Tighten mounting screw and replace capstan belt cover.

5-22. PRELIMINARY SERVO ADJUSTMENTS. The test points and potentiometers used in this procedure are located on the capstan and reel servo board. This board is located as shown in figure 5-8. If the potentiometers are suspected to be far out of alignment, preset their resistances as follows:

a. With transport disconnected from electrical power, remove control panel.

b. Verify tension setting of torsion springs (paragraph 5-14).

c. Remove capstan and reel servo board (after removing control logic board).

d. Adjust supply reel dc offset R53 and takeup reel dc offset R70 each to 500 ohms. (Measure between pin 1 and pin 2 of potentiometers.)

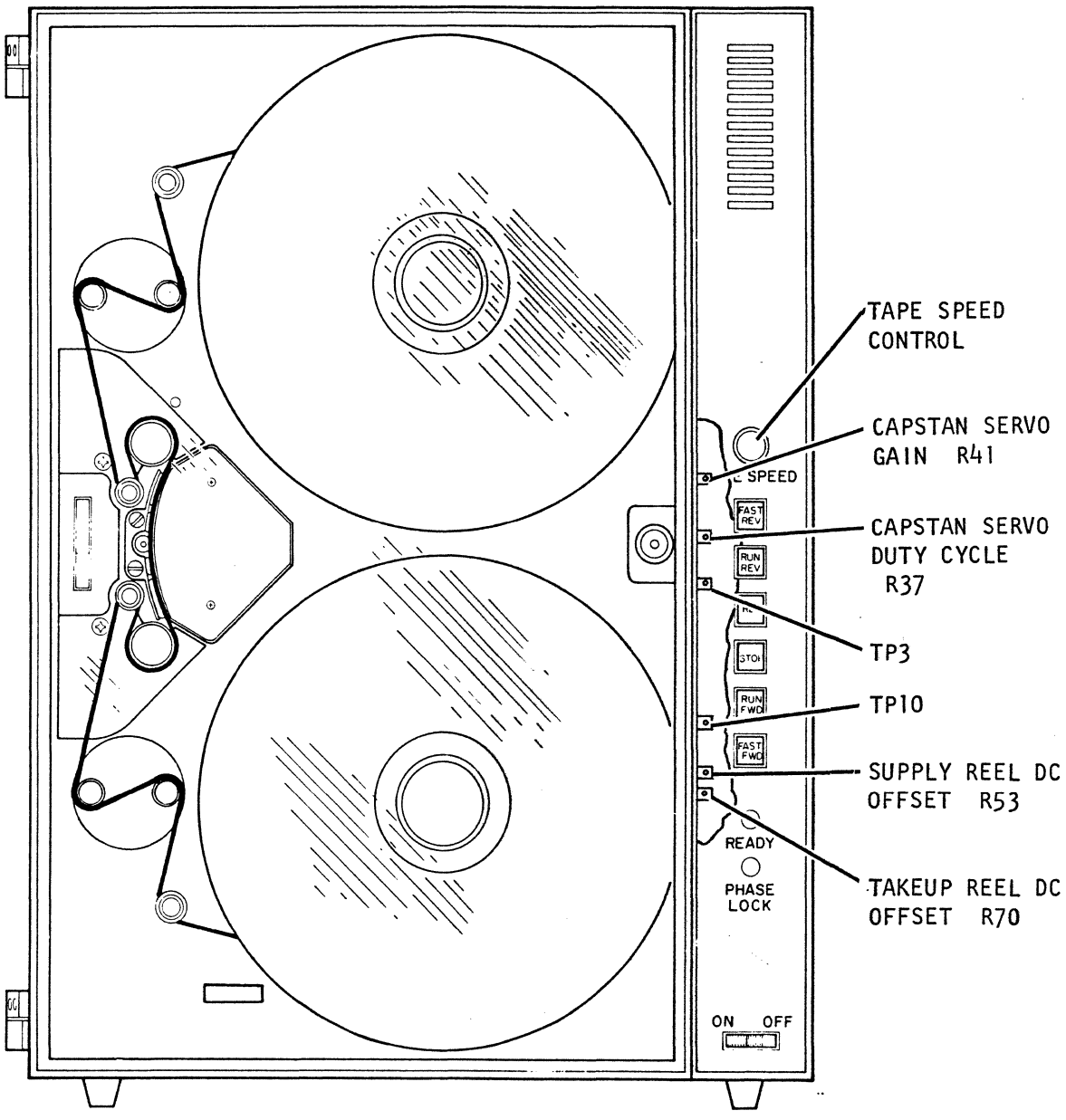


Figure 5-8. 12-401D Tape Transport Adjustments

e. Set capstan servo duty cycle potentiometer R37 to 1000 ohms. (Measure between pin 1 and pin 2 of potentiometer.)

f. Set capstan servo gain potentiometer R41 to 30K ohms. (Measure between pin 2 and pin 3 of potentiometer.)

g. Replace circuit boards and temporarily replace control panel screws in order to hold boards in place.

5-23. FINAL REEL SERVO ADJUSTMENTS. The final capstan and reel servo adjustments are made using the following procedures:

a. Thread tape on tape transport and reconnect electrical power.

b. Set tape speed to 3-3/4 inches per second and put transport in run mode.

c. Adjust potentiometers R53 (supply) and R70 (takeup) so that their respective tension sensor rollers are horizontal (in the middle of their travel).

d. Check position of servos at each tape speed.

5-24. FINAL CAPSTAN SERVO ADJUSTMENTS. The final capstan servo adjustments are made using the following procedures:

a. Thread tape on tape transport.

b. Connect oscilloscope between TP3 (orange) and ground at TP10 (black).

c. Set tape speed to 60 inches per second and put transport in run mode.

d. Adjust capstan servo duty cycle potentiometer R37 for a 50 percent duty cycle square wave.

e. Set tape speed to 7-1/2 ips. Adjust the capstan servo gain potentiometer R41 for minimum pulse jitter, thus: turn R41 clockwise until oscillations occur, at this point turn R41 counterclockwise until oscillations disappear. Then turn R41 counterclockwise two turns.

f. Check all other speeds, including the fast modes, for a phase lock indication. Make any minor readjustment of R41 to prevent oscillations or excessive jitter.

g. If the tape lock servo accessory is installed, repeat steps e and f while operating in the tape mode with a reference signal prerecorded at 7-1/2 ips. After adjustments are complete, check all speeds for proper phase lock without excessive jitter.

NOTE

Refer to the System Operation and Maintenance manual, Section III for the procedures to record a tape reference signal.

5-25. TROUBLESHOOTING.

5-26. Troubleshooting of the 12-401D Tape Transport requires familiarization with the mechanical operations as well as a thorough understanding of the principles of operation. Service personnel are urged to study the Theory of Operation in Section IV of this manual. The schematic diagrams contained in Section VII of this manual also prove helpful during circuit analysis, tracing signals between components and interconnecting assemblies, and establishing test points.

CAUTION

The following steps require the use of an extender card holder which may be used for either the capstan and reel servo board or for the control logic board. When inserting the extender card holder into the mating connector for its intended use, the other board must be removed and reinserted simultaneously with the extender card. This precludes possible damage to components mounted on the other card when the extender card holder is inserted into its mating connector.

5-27. CAPSTAN SERVO TROUBLESHOOTING PROCEDURE. Refer to figure 7-3 and disconnect the pair of black and yellow shielded wires from A1A2TB1, pins 1 and 2, respectively. Insert a 5 ohm, 200 watt resistor between pins 1 and 2 in place of the wires just removed. Next, disconnect the green and yellow wires from pins 3 and 4, respectively. Insert a sine wave generator hot lead to pins 3 and 4 in place of the tachometer amplifier output wires just removed and sine wave generator ground to A1A2TB1-11. This action disables the capstan motor and substitutes a sine wave generator for the tachometer amplifier output. The following steps will check the proper operation of the closed loop servo amplifier or aid in the isolation of a malfunction in the circuit.

a. Set output of sine wave generator to a frequency of 12.5 kHz and 10 V p-p which corresponds to the normal tach frequency of 7-1/2 ips.

b. Place transport in run mode without tape reels mounted on transport, thus:

1. Disable light sensors by blocking light source with a piece of paper or small length of magnetic tape.

2. Position tape sensor rollers to the active position with a loop of lacing cord, wire, or other suitable device to keep them stationary.

3. Operate the power ON switch.

4. Set TAPE SPEED SELECTOR to 7-1/2 ips.

5. Allow 10 minute transport warmup time.

6. Press the RUN FWD pushbutton.

7. The reel hubs should rotate, while the capstans do not. The lights should be normal.

c. Refer to figure 7-1. The capstan servo loop can now be checked for proper operation, thus:

1. Check TP6 for normal reference signal.

2. Check U13-8 for a signal approximately close to what the normal TACH "A" signal should be. It may be necessary to adjust the amplitude output of the sine wave generator to approximately 10 volts peak-to-peak.

3. Check U14-8 for a 240 nanosecond pulse, next check U15-4 for a 160 nanosecond pulse. This will determine the correct operation of the reference pulse generator.

4. Check U15-6 for a 160 nanosecond pulse. Readjustment of the amplitude output of the sine wave generator may be made while observing the output of U15-6. Set the sine wave generator for optimum pulse output of U15-6. This will determine the correct operation of the TACH/TAPE pulse generator.

5. Refer to the logic diagram of the SN7473N dual J-K flip-flop for the J-K input pins and the Q, $\overline{Q}$ output pins. The flip-flops should operate according to the truth table.

J	K	C	Q^n	Q^{n+1}
0	0	1	Q	Q
0	1	1	Q	0
1	0	1	Q	1
1	1	1	Q	$\overline{Q}$

6. Slowly adjust the output frequency of the sine wave generator until its frequency equals the reference frequency; the middle flip-flop should toggle while the upper flip-flop Q output should be a logical "1". Likewise, the lower flip-flop Q should also be a logical "1". This set of circumstances says the U20 flip-flop is set while the lower U17 flip-flop is reset and corresponds to the Phase Lock operating circuit condition.

7. Adjust the sine wave generator frequency to be slightly higher than 12.5 kHz. This represents a TOO FAST situation. Now the upper U20 flip-flop should toggle while the middle U17 flip-flop output of pin 13 should be a logical "1" and the lower U17 flip-flop output pin 8 should also be a logical "1". Again this represents the TOO FAST conditions by the upper U20 flip-flop toggling, while the middle U17 flip-flop is reset and the lower U17 flip-flop is set.

8. Adjust the sine wave generator frequency to be slightly lower than 12.5 kHz. This represents a TOO SLOW situation. The lower U17 flip-flop will toggle while the middle U17 flip-flop will have a logical "0" output and the upper U20 flip-flop output will be a logical "1".

9. Repeat the procedures of steps 5, 6, and 7 (above) and check the latch circuit U22, output pin 6. The TOO FAST case will cause a logical "0" output. This output most likely will be a toggle type output due to the difficulty in matching the frequency of the sine wave generator to the reference signal without experiencing a drift of the sine wave generator, however, it gives a good circuit indication.

10. Check the circuit of U25-8 at TP3. Since a NAND gate will have a logical "1" output for any logical "0" input, the circuit will toggle while one input is held at a logical "1" and the other input switches from a logical "0" to a logical "1". The comparator output enable should be held at a logical "1" while the comparator input switches from logical "0" to logical "1" according to the frequency of the sine wave generator.

11. Check that the comparator output enable U25-10 is a logical "1". If the comparator output enable is a logical "0", manually turn the upper capstan in a forward direction (clockwise) until the comparator output enable switches to a logical "1". Monitor TP3 will toggle when in phase lock; will be a logical "1" when TOO SLOW, and a logical "0" when TOO FAST (will reset to a logical "1" after approximately 3/4 of a second due to the too fast delay logic).

12. The operation of U23, U21, U24, Q8, and Q9 can likewise be dynamically checked by reducing the sine wave generator output frequency to be slightly lower than 12.5 kHz (TOO SLOW). This will ensure that the output of the comparator gate U25-8 is a high level or a logical "1". With this input, all of the operational amplifiers and transistors that make up the rest of the capstan servo amplifier may be checked. Refer to table 5-3 for typical voltage measurements.

13. This troubleshooting procedure may be used to check the closed loop capstan servo system whenever an abnormal situation warrants a check of the circuits. Malfunctions in the circuit can be determined by abnormal switching or logical level outputs of the various circuit stages. After troubleshooting, reconnect wires and reinstall the printed circuit board.

5-28. Table 5-3 lists typical voltage measurements for the capstan servo amplifier under normal operating conditions.

TEST POINT	TYPICAL VOLTAGE MEASUREMENTS
U23-4	+3.0 to +3.6 Vdc
U23-5	+3.0 to +3.6 Vdc
U23-10	+3.2 to +3.7 Vdc
U21-4	+2.2 to +3.2 Vdc
U21-5	+1.4 to +3.0 Vdc
U21-10	-5.6 to -8.0 Vdc
U24-4	0 Vdc
U24-5	-0.6 to -2.2 Vdc
U24-10	-9.0 to -11.0 Vdc
Q8 Base	-8.5 to -9.8 Vdc
Q8 Emitter	0 Vdc
Q8 Collector	+16 to +17 Vdc
Q9 Base	+17 to +18 Vdc
Q9 Emitter	+16 to +17 Vdc
Q9 Collector	+17 to +18 Vdc
Connector A1P5-D	+15 to +16 Vdc
Connector A1P5-E	+15 to +15.5 Vdc
Connector A1P5-3	+0.5 Vdc
Connector A1P5-L	+1.4 Vdc

Table 5-3. Typical Voltage Measurements for the Capstan Servo Amplifiers

5-29. REEL SERVO TROUBLESHOOTING PROCEDURE. Troubleshooting the reel servo circuit is accomplished using the following steps:

a. Place the tape transport in the run mode without tape reels mounted on the transport as follows:

1. Disable the light sensors by blocking the light source with a piece of paper or small length of magnetic tape.

2. Position the tape sensor rollers to the active position with a loop of lacing cord, wire, or other suitable device to keep them stationary.

3. Operate the power ON switch.

4. Set the TAPE SPEED SELECTOR switch to 7-1/2 ips, and allow 10 minute transport warmup time.

5. Press the RUN FWD pushbutton.

b. The reel hubs and capstans should now rotate. The indicator light should be normal.

c. Carefully and without losing tape tension remove the loop of lacing cord from the lower (takeup) tension roller.

d. Refer to table 5-4 and schematic figure 7-1 for the typical reel servo voltage measurements and, while monitoring the specified test points listed in table 5-4, move the lower tension roller over its full range.

CAUTION

Use care to avoid losing tape tension by actuating the microswitch which will stop the transport. Should this happen, reposition the lower roller and press the RUN FORWARD switch again.

TEST POINT	TYPICAL VOLTAGE MEASUREMENTS
U1 and U4-4	+0.3 to +0.4 Vdc
U1 and U4-5	+0.2 Vdc
U1 and U4-10	-5 to +3 Vdc
U2 and U3-4	-10 mV to +10 mVdc
U2 and U3-5	0 Vdc
U2 and U3-10	-4 to +10 Vdc
Q11 and Q14 Base	-0.7 to +2 Vdc
Q11 and Q14 Emitter	0 to +1.5 Vdc
Q11 and Q14 Collector	+1.5 to +17 Vdc
Q12 and Q13 Base	+1 Vdc with 1 V p-p noise
Q12 and Q13 Emitter	+0.25 Vdc with 1 V p-p noise
Q12 and Q13 Collector	+0.25 Vdc with 1 V p-p noise

Table 5-4. Typical Reel Servo Voltage Measurements

e. Replace the loop of string on the lower tension roller.

f. Carefully and without losing tape tension, remove the loop of lacing cord from the upper (supply) tension roller and repeat step d by moving the upper tension roller through its range.

g. Comparing the actual voltage measurements to the typical voltage measurements listed in table 5-4 should pinpoint any defective component in the reel servo circuit. Do not overlook the possibility of a defective reel motor should the actual voltage measurements compare favorably with the voltages listed in table 5-4.

h. After troubleshooting, reconnect wires and install the printed circuit board.

5-30. REMOVAL OF HEAD ASSEMBLY. Troubleshooting of the record or reproduce electronics and certain transport maintenance procedures may require removal of the head assembly. Proceed as follows:

a. Disconnect power.

b. Remove the trim plate cover on the top of the head assembly.

c. Hold the head assembly with one hand and remove the three Allen screws securing the head assembly to the transport precision plate. When removing the Allen screws, back them out approximately one turn at a time. A 9/64 Allen wrench is required for removal of the Allen screws.

d. Remove the head assembly.

e. To replace the head assembly, carefully align the guide pins and ensure that the mating plug and connectors are in their proper position. Alternately tighten each screw gradually until the assembly is held securely in place. Replace the trim plate cover.

f. Individual head stacks are not field replaceable. Should an individual head stack require replacement, it will be necessary to ship the head assembly to the Pasadena plant for installation of the required head stack.

5-31. TAPE TRANSPORT FAULTS. Refer to Section V of the system manual for a list of common faults and possible causes.

5-32. REPAIR.

5-33. Repair of this magnetic tape record/reproduce equipment should be undertaken only by technicians experienced in the maintenance of instrumentation grade tape equipment. The printed circuit boards should be repaired only by personnel experienced in printed wiring techniques. It is recommended that repair be limited to replacement of defective components and adjustment of controls.

5-34. Be sure that replacement parts are of the correct type and value, and that they are known to be good. When removing and replacing defective components, be careful not to burn or damage the surrounding circuit parts, particularly on printed circuit boards. When installing a new part, place it in the exact position as the one replaced and, after replacement, inspect the circuit board for evidence of cold solder joints, solder splashes, and insecurity of mounting.

5-35. COMPONENT IDENTIFICATION.

5-36. The various assembly drawings in Section VI locate some of the major components. All components in the transport and amplifier mother board have reference designators prefixed with "A1" and "A2", respectively. The following list is of the reference designations of the major subassemblies:

Transport Area	A1
Preamplifiers	A1A1
Preamplifiers, Channels 1-4	A1A1A1
Preamplifiers, Channels 5-7	A1A1A2
Preamplifiers, Channels 8-11	A1A1A3
Preamplifiers, Channels 12-14	A1A1A4
Voltage Regulator	A1A1A5
Transport Plate	A1A2
Control Logic	A1A3
Capstan and Reel Servo	A1A4
Power Supply	A1A5
LED Footage Counter and Control Board	A1A6
Counter Display and Shuttle Control	A1A7
Amplifier Case	A2
Amplifier Connector Board	A2A1
Channels 1-7	A2A2
Channels 8-14	A2A3

5-37. FIELD REPAIR SERVICE. Refer to Section V in the system manual for information on how to obtain Bell & Howell field repair service.

5-38. FACTORY REPAIR SERVICE. Refer to Section V of the system manual for factory repair service information.

SECTION VI

PARTS LIST

6-1. GENERAL.

6-2. Appropriate part lists and illustrations for the 12-401D Tape Transport, Bell & Howell part number 541200, covered by this manual follow the instructions given below. The part lists (tables 6-1 and 6-2) include Bell & Howell DATATAPE Division part number, description, figure and index and/or schematic reference symbol, and where applicable, the manufacturer's or military part number for each component.

6-3. MANUFACTURER'S CODES.

6-4. Manufacturer's code symbols used in the part lists are tabulated in the System manual with the manufacturer's name and address. All code symbols are in accordance with the Federal Supply Code for Manufacturers Cataloging Handbooks H 4-1 and H 4-2.

6-5. ORDERING REPLACEMENT PARTS.

6-6. When ordering replacement parts refer to Section VI of the System manual for ordering instructions.

6-7. PARTS LOCATION ILLUSTRATIONS.

6-8. Figures 6-1 through 6-15 illustrate the location of components in the tape transport.

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 1 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	541200-0002	4020A Transport (1/2-Inch)	1	6-1	14028	
	541200-0005	4020A Transport (1-Inch)	1	6-1	14028	
2	538008	Kit, cable and grounding power input	1		14028	
3	538008-0001	Power Cable, ac	1		14028	
4	9774-0014	Terminal, lug, solderless, insul, 14-16 AWG, stud size 6	3			MS25036-106
5	158617-0010	Terminal, lug, quick disconnect, blu for 0.250 x 0.032 tab	2		14726	S0923ST1
6	538008-0002	Strap, ground	1		14028	
7	249547-9002	Lug, solderless 8 AWG, stud size 8	2		98410	D-356-08
8	9774-0006	Terminal, lug, solderless, insul, 14-16 AWG, stud size 8	1			MS25036-153
9	536461	Transport and Frame Assembly	1	6-1/10,6-6	14028	
10	476055	Guide, pcb, bottom	1	6-6/3	14028	
11	476056	Guide, pcb, top	1	6-6/4	14028	
12	476062	Skid, transport	2	6-6/6		
13	539751	Mount, power switch	1		14028	
14	539752	Bracket, mounting, card guide	1		14028	
15	518720-0001	Handle, transport (machined)	2		14028	
16	476044-0001	Pin, pivot	2	6-6/11		
17	476044-0002	Pin, pivot	2	6-6/12		
18	476026-0001	Hinge, rear cover	1	6-6/13	06912	CAT NO. S30106655

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 2 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	475068-0001	Catch, bullet	2	6-6/14	99536	11026-FW18
2	379675	Block Hinge	2	6-6/16		
3	518682	Cover, base	1	6-6/17		
4	523691	Insulator	1	6-6/18		
5	520449-0002	Mount, resilient	4	6-6/19		
6	476420	Switch, rocker	1	A1A2S2		
7	476176	Filter, rfi, line	2	A1A2FL1, FL2		
8	211308-0547	Pin, grooved, headless 1/8 x 1, steel	1	6-6/31	83584	
9	379694	Pin, drive	1	6-6/32		
10	212498-0016	Washer, flat, nylon	4	6-6/33	05616	182 SC
11	39832-0125	Ring, retaining 0.125 to 0.127 shaft	2	6-6/36	79136	5555-12-MD
12	39832-0370	Ring, retaining 0.373 to 0.379 shaft	2	6-6/37	79136	5555-37-MD
13	519049-0002	Cable, power switch	1	6-6/41	14028	
14	475069	Terminal, tab quick disconnect	4	6-6/46	75382	KT36
15	173404-0003	Nut, anchor, floating thread 8-32UNC-3 B	2	6-6/52	72962	52LHTA 521-82
16	529852	Transport Assembly, tape	1	6-1/11,6-2	14028	
17	379705-0001	Belt, capstan drive	1	6-2/6		
18	531990	Supply/Upper Reel Motor and Brake Assembly	1	6-2/10	14028	

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 3 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	532701	Motor, reel	1		14028	
2	476082	Motor, series wound, dc torque, 15 Vdc 130 oz-in.	1		27304	402-19
3	155527-0004	Ferrule RF Cable Grounding, orange	1		00779	323933
4	158617-0013	Terminal, lug, quick disconnect, red for 0.187 x 0.020 tab	3		14726	S09624ST1
5	535907	Clamp, hub, reel	1		14028	
6	532700	Brake Assembly, disk	1		14028	
7	379358	Disc, brake	1		14028	
8	379448-0002	Hub Brake Disk	1			
9	379351	Bar Pinch Brake	2			
10	379355	Pad, friction brake	2			
11	39832-0125	Ring, retaining 0.125 to 0.127 shaft	4		79136	5555-12-MD
12	379354	Roller Brake	2		14028	
13	379352	Spacer Spring	2			
14	250466-0007	Spring, helical, ext and comp, music wire	1		84830	LC-032B-5 MUSIC WIRE
15	211308-0544	Pin, grooved, headless 1/8 x 5/8, steel	2		83584	
16	531990-0099	Bracket and Component Subassembly	1		14028	

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 4 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	379357	Solenoid	1	L1		
2	531991	Bracket, brk and comp mtg sply	1		14028	
3	379356	Shaft Pinch Bar	2			
4	526095	Block, mounting photo-sensor	1		14028	
5	379449	Adapter Switch Actuator Brake	1			
6	247894-0001	Socket, power transistor	1		22753	PTS-1
7	534465-0001	Photo-Sensor Assembly	1	CR2	14028	
8	48977-0003	Grommet, caterpillar	1		03296	G51H-C
9	248422-0012	Insulator, transistor mounting, TO-3/TO-66	2		08289	TW-150-193-100
10	248422-0007	Insulator, transistor mounting	2		08289	MW-750-195
11	248422-0009	Insulator, transistor mounting	2		78189	4706-05-02-CAD PLATE
12	248422-0001	Insulator, transistor mounting	1		08289	DM-101 OR DM-103-SL
13	371763-1005	Board, terminal, barrier section 10-ext feed thru	1	TB1	07859	33010
14	202790-0016	Cap, fixed, ceramic 0.1 uF ±20%, 100 Vdc	1	C1	56289	TG-P10
15	70017-5083	Res, fixed, wirewound 0.50 ohm ±3%, 25 W	1	R2	81637	RH25-G-R50-H

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 5 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	7140-1015	Res, fixed, composition 100 ohm ±5%, 2.0 W	1	R1		RCR42G101JS
2	172291-4007	Res, wirewound, power, ch/mt, 20.0 ohm ±3%, 10 W	1	R3	91637	RH10-20-3 PCT
3	372295-0003	Diode, rectifier 1.0A 200 V, 1N4003	1	CR1	04713	1N4003
4	471930-0007	Cap, fixed, electrolytic 25.0 uF -10 +75%, 50 V	1	C1	14655	NLW 25-50
5	518197	Switch, sensitive, SPDT	1	S1	19635	E-63-76HA REF
6	475222	Transistor, MJE3055	2	Q1,3	04713	MJE3055
7	246014-0003	Transistor, NPN, power 2N3055	1	Q2	86684	2N3055
8	7127-0008	Terminal, lug, solder screw size 4	1		79963	805-NO.4
9	19544-0302	Setscrew, cup point 8-32 x 3/16 stl blk cad	2		56878	
10	19544-0305	Setscrew, cup point 8-32 x 3/8 stl blk cad	2		56878	
11	371763-1001	Board, terminal, barrier section 10-std twin screw	1	A1A2TB1	07859	33010
12	529109	Plate, mtg, tape transport	1	6-2/1	14028	
13	479579	Head Mtg Plate Assembly	1	6-2/3		
14	473122	Plate, head mount	1		14028	
15	473120	Bracket	1			

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 6 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	70095-0044	Pin, straight, headless 1/4 x 0.1250 dia cres	2		08547	
2	476120-0001	Motor, tachometer generator	1	6-2/4	14028	
3	379571	Motor, tachometer	1		14028	
4	476114	Capstan and Pulley	1		14028	
5	476116	Cap	1		14028	
6	9774-0068	Terminal, lug, solderless, insul, 18-22 AWG, stud size 2	6		14726	SS22504
7	9774-0013	Terminal, lug, solderless, insul, 18-22 AWG, stud size 8	1			MS25036-149
8	531992	Reel Motor and Brake Assembly take-up/lower	1	6-2/11	14028	
9	532701	Motor, reel	1		14028	
10	476082	Motor, series wound, dc torque, 15 Vdc, 130 oz-in.	1		27304	402-19
11	155527-0004	Ferrule RF Cable Grounding orange	1		00779	323933
12	158617-0013	Terminal, lug, quick disconnect, red for 0.187 x 0.020 tab	3		14726	S09624ST1
13	535907	Clamp, hub, reel	1		14028	
14	532700	Brake Assembly, disk	1		14028	
15	379358	Disc, brake	1		14028	
16	379448-0002	Hub Brake Disk	1			

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 7 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	379351	Bar Pinch Brake	2			
2	379355	Pad, friction brake	2			
3	39832-0125	Ring, retaining 0.123 to 0.127 shaft	4		79136	5555-12-MD
4	379354	Roller Brake	2		14028	
5	379352	Spacer Spring	2			
6	250466-0007	Spring, helical, ext and comp, music wire	1		84830	LC-032B-5 MUSIC WIRE
7	211308-0544	Pin, grooved, headless 1/8 x 5/8, steel	2		83584	
8	531992-0099	Bracket and Comp Subassembly Reel Motor and Brake Assembly	1		14028	
9	379357	Solenoid	1	L1		
10	531993	Bracket Brake and Comp Mtg, take-up	1		14028	
11	379356	Shaft Pinch Bar	2			
12	526095	Block, mounting photo-sensor	1		14028	
13	379449	Adapter Switch Actuator Brake	1			
14	247804-0001	Socket, power transistor	1		22753	PTS-1
15	534465-0001	Photo-Sensor Assembly	1		14028	
16	540252	Lead, electrical	1		14028	
17	248422-0012	Insulator, transistor mounting, TO-3/TO-66	2		08289	TW-150-193-100

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 8 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	248422-0007	Insulator, transistor mounting	2		08289	MW-750-195
2	248422-0009	Insulator, transistor mounting	2		78189	4706-05-02-CAD PLATE
3	248422-0001	Insulator, transistor mounting	1		08289	DM-101 OR DM-103-SL
4	371763-1005	Board, terminal, barrier section 10-ext feed thru	1	TB1	07859	33010
5	202790-0016	Cap, fixed, ceramic 0.1 uF ±20%, 100 Vdc	1	C2	56289	TG-P10
6	70017-5083	Res, fixed, wirewound 0.50 ohm ±3%, 25 W	1	R2	91637	RH25-G-R50-H
7	7140-1015	Res, fixed, composition 100 ohm ±5%, 2.0 W	1	R1		RCR42G101JS
8	172291-4007	Res, wirewound, power, ch/mt, 20.0 ohm ±3%, 10 W	1	R3	91637	RH10-20-3 PCT
9	372295-0002	Diode, rectifier 1.0A 200 V, 1N4003	1	CR1	04713	1N4003
10	471930-0007	Cap, fixed, electrolytic 25.0 uF -10 +75%, 50 V	1	C1	14655	NLW 25-50
11	518197	Switch, sensitive, SPDT	1	S1	19635	E-63-76HA REF
12	475222	Transistor, MJE3055	2	Q1,3	04713	MJE3055
13	246014-0003	Transistor, NPN, power 2N3055	1	Q2	86684	2N3055
14	7127-0008	Terminal, lug, solder screw size 4	1	E1	79963	805-NO.4

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 9 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	19544-0302	Setscrew, cup point 8-32 x 3/16 stl blk cad	2		56878	
2	19544-0305	Setscrew, cup point 8-32 x 3/8 stl blk cad	2		56878	
3	379342	Capstan Spindle and Direct Sensor	1	6-2/12		
4	19785-0042	Lamps, general 6.3 volt midget fl	1	A1A2A6DS1	71744	381
5	476119	Capstan and Spindle Assembly	1		14028	
6	379587	Reflector, light sensor	3			
7	379584	Housing Direction Sensor	1			
8	379588-0001	Sensor Direction	1		14028	
9	379588	Board, printed wiring	1		14028	
10	376362	Transistor	4	A1A2A6Q1, 2,3,4	17803	FPT100
11	379547	Holder, lamp	1			
12	379586	Shield Lamp Sensor	1			
13	379585	Rotor Reflector Sensor	1			
14	541217	Preamplifier, housing	1	6-2/18,6-8	14028	
15	532738-0001	Bracket, electrical conn	1	6-8/4	14028	
16	532738-0002	Bracket, electrical conn	1	6-8/5	14028	
17	519550-0010	Connector, electrical solder tabs	5	A1J20A, J20B, J21A, J21B, J24	81312	HSD10S0

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 10 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	519550-0099	Key, polarizing	5	6-8/18	81312	109-9892
2	541217-0099	Cable Assembly	1		14028	
3	536086-0001	Shield, cable preamplifier housing	1	6-8/1	14028	
4	473121	Bracket	1	6-8/2	14028	
5	473125	Spacer	2	6-8/3	14028	
6	169811-0004	Cable, shielded 2 conductor, AWG 24	1	6-8/6	17217	G12A100
7	9774-0013	Terminal, lug, solderless, insul, 18-22 AWG, stud size 8	1	6-8/7	96906	MS25036-149
8	372889-0001	Connector, electrical 44 pins	1	A1J22C	81312	SRE-44-P-N
9	547432	Bracket, loudspeaker and display assy	1	6-1/28,6-13	14028	
10	547433	Bracket	1	6-13/1	14028	
11	547434	Clamp, speaker	1	6-13/2	14028	
12	547941-0001	Loudspeaker	1	6-13/5	14028	
13	547408	Counter/Display and Shuttle Control Assy	1	6-13/6,6-14	14028	
14	547409	Printed Wiring Board	1	6-14/1	14028	
15	477674-0010	Adapter, plug	1	6-14/J2	19112	102-16-CC-B-LL
16	547549-0004	Indicator, digital, led	1	6-14/U10	28480	5082-7415
17	526155-0001	Switch, toggle	1	6-14/S9	09353	7101-C
18	526155-0004	Switch, toggle	1	6-14/S8	09353	7105-C

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 10A of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	175431-0212	Screw, machine, pan head 4-40 x 0.188	4	6-13/10	96906	MS35206-212
2	801415-0003	Spacer, post, 1/4 hex	4	6-13/12	06540	9739-A-0440-/17
3	7158-0008	Nut, self locking, hex 4-40	4	6-13/14	96906	MS21044N04
4	800477-0008	Connector, plug, electrical	1	6-13/19	81312	JF3P-1S-ACD
5	525534-0009	Cable, twisted pair, 22 awg, wht & blk	A/R	6-13/20	14028	
6	531913	Bracket, power input	1	6-1/40	14028	
7	540996-0001	Voltage Regulator, preamplifier	1	6-1/27,6-12	14028	
8	540996	Board, printed wiring	1	6-12/2	14028	
9	363247-1014	Screw, machine, pan head 4-40 x 5/16 steel cad pl	2	6-12/7	96906	MS51957-14
10	32277-0008	Nut, plain, hex, 4-40	2	6-12/8	96906	MS35649-244
11	479699-0049	Cap, fixed, ceramic 0.1 uF ±10%, 50 Vdc	4	C1 thru 4	81349	CK05BX104K
12	471863-0004	Cap, fixed, tantalum 10 uF ±20%, 20 Vdc	2	C5,6	31433	T322C106-M020AS
13	248422-0014	Insulator, bushing	2	6-12/12	04713	B08853A001
14	526858-0012	Integrated Circuit, negative voltage regulator	1	VR2	27014	LM320T-12.0
15	527146-0012	Integrated Circuit, type 340	1	VR1	27014	LM340T-12
16	248422-0013	Insulator, bushing	4	6-12/15	04713	B51547F015
17	248422-0008	Washer, compression	2	6-12/16	78189	4704-04-02-CAD PLATE

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 11 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	539746	Control Logic and Bracket Assembly	1	6-1/12,6-4	14028	
2	539747	Bracket, control panel	1	6-4/1	14028	
3	539755-0001	Circuit Card Assembly control logic	1	6-4/2,6-5	14028	
4	246954	Diode Signal Switching 25 V work volt 1N4154	4	CR1,2, CR4,5	03508	1N4154
5	372295-0001	Diode, rectifier 1.0 A 100 V, 1N4002	1	CR3	04713	1N4002
6	471863-0008	Cap, fixed, tantalum 0.1 uF ±20%, 35 Vdc	24	C1,4 thru C11,20,21, C23,24,26 thru C34, C36,38	31433	T320A104-M35AS
7	70143-0070	Cap, fixed, tantalum 0.01 uF ±20%, 100 Vdc	2	C12,13	81349	M39003/01-2430
8	374986-0056	Cap, fixed, tantalum 0.47 uF ±10%, 35 Vdc	1	C14	31433	T310A474K035AS
9	371916-0030	Cap, fixed, mylar 0.1 uF ±20%, 100 Vdc	1	C15	56289	225P10401WD3
10	479699-0037	Cap, ceramic 0.01 uF ±10%, 100 Vdc	1	C16	72982	CK05BX103K
11	215095-0532	Cap, fixed, mylar 0.0033 uF ±10%, 80 V	2	C17,41	56289	192P3329R8
12	215095-0112	Cap, fixed, mylar 0.00056 uF ±10%, 200 V	2	C18,19	56289	192P56192
13	471863-0004	Cap, fixed, tantalum 10.0 uF ±20%, 20 Vdc	2	C2,40	31433	T320B106-M20AS
14	215095-0442	Cap, fixed, mylar 0.33 uF ±10%, 80 V	1	C22	56289	192P3349R8

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 12 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
				6-5		
1	471863-0007	Cap, fixed, tantalum 1.2 uF ±20%, 35 Vdc	1	C25	31433	T320A125-M35AS
2	471930-0003	Cap, fixed, electrolytic 100 uF -10 +75%, 16 V	1	C3	14655	NLW 100-16
3	374550-0002	Cap, variable 9.0 to 35 pF	1	C35	15450	538-011 9.0-35PF A
4	371916-0002	Cap, fixed, mylar 0.001 uF ±10%, 100 Vdc	1	C37	56289	225P10291WD3
5	371916-0014	Cap, fixed, mylar 0.0047 uF ±10%, 100 Vdc	1	C39	56289	225P47291WD3
6	472460-0501	Relay, reed type 1, form A	1	K1	15636	RA30381051
7	471472	Transistor, NPN 2N3947	6	Q1,2,4, Q5,6,14	04713	2N3947
8	375028-0002	Transistor	1	Q3		
9	471927	Transistor, NPN 2N2219	7	Q7 thru Q13	04713	2N2219
10	471922-5132	Res, fixed, metal oxide 51K ohm ±2%, 1/4 W	2	R1,3	24546	C4-51K OHM 2 PCT
11	471922-3622	Res, fixed, metal oxide 3.6K ohm ±2%, 1/4 W	2	R10,16	24546	C4 3600 OHM 2 PCT
12	471922-1822	Res, fixed, metal oxide 1.8K ohm ±2%, 1/4 W	2	R11,17	24546	C4-1800 OHM 2 PCT
13	471922-1032	Res, fixed, metal oxide 10K ohm ±2%, 1/4 W	4	R12,18, R21,67	24546	C4-10K OHM 2 PCT
14	471922-4732	Res, fixed, metal oxide 47K ohm ±2%, 1/4 W	2	R2,69	24546	C4-47K OHM 2 PCT

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 13 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
				6-5		
1	471922-2222	Res, fixed, metal oxide 2.2K ohm ±2%, 1/4 W	8	R20,24, R29,38, R43,48, R56,61	24546	C4-2200 OHM 2 PCT
2	471922-1012	Res, fixed, metal oxide 100 ohm ±2%, 1/4 W	14	R26,27, R33,34, R36,40, R41,45, R46,52, R53,58, R59,86	24546	C4-100 OHM 2 PCT
3	471922-5622	Res, fixed, metal oxide 5.6K ohm ±2%, 1/4 W	1	R32	24546	C4-5600 OHM 2 PCT
4	471922-2712	Res, fixed, metal oxide 270 ohm ±2%, 1/4 W	1	R4	24546	C4-270 OHM 2 PCT
5	471922-4722	Res, fixed, metal oxide 4.7K ohm ±2%, 1/4 W	26	R5,25,28, R30,31, R35,37, R39,42, R44,47, R51,55, R57,60, R65,71, R72 thru R79,84	24546	C4-4.7K OHM 2 PCT
6	471922-3332	Res, fixed, metal oxide 33K ohm ±2%, 1/4 W	2	R50,54	24546	C4-33K OHM 2 PCT

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 14 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
				6-5		
1	471922-1022	Res, fixed, metal oxide 1K ohm ±2%, 1/4 W	7	R6,13,19, R49,63, R70,83	24546	C4-1K OHM 2 PCT
2	471922-2212	Res, fixed, metal oxide 220 ohm ±2%, 1/4 W	2	R62,66	24546	C4-220 OHM 2 PCT
3	471922-2402	Res, fixed, metal oxide 24 ohm ±2%, 1/4 W	1	R64	24546	C4-24 OHM 2 PCT
4	471922-1042	Res, fixed, metal oxide 100K ohm ±2%, 1/4 W	1	R68	24546	C4-100K OHM 2 PCT
5	471922-1512	Res, fixed, metal oxide 150 ohm ±2%, 1/4 W	2	R7,14	24546	C4-150 OHM 2 PCT
6	471922-2022	Res, fixed, metal oxide 2K ohm ±2%, 1/4 W	2	R8,15	24546	C4-2K OHM 2 PCT
7	471922-9102	Res, fixed, metal oxide 91 ohm ±2%, 1/4 W	1	R80	24546	C4-91 OHM 2 PCT
8	471922-4702	Res, fixed, metal oxide 47 ohm ±2%, 1/4 W	2	R81,82	24546	C4-47 OHM 2 PCT
9	471922-3322	Res, fixed, metal oxide 3.3K ohm ±2%, 1/4 W	3	R9,22,23	24546	C4-3300 OHM 2 PCT
10	471933	Integrated Circuit 74H00 quad 2-input NAND	1	U1	01295	SN74H00N,J
11	471934	Integrated Circuit 7400 quad 2-input NAND	6	U10,12, U15,17, U22,32	01295	SN7400N,J
12	471941	Integrated Circuit 7404 hex inverter	4	U11,16, U20,28	01295	SN7404N,J
13	471936	Integrated Circuit 7410 triple 3-input NAND	3	U13,14,21	01295	SN7410N,J

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 15 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
				6-5		
1	471937	Integrated Circuit 7420 dual 4-input NAND	2	U8,19	01295	SN7420N,J
2	520001	Integrated Circuit LM339 quad V comparator	1	U25	27014	LM339N
3	480621	Integrated Circuit 74161 sync 4-bit bin cntr	4	U26,29, U31,34	01295	SN74161N,J
4	480603	Integrated Circuit 74175 quad D flip-flop	1	U27		
5	471939	Integrated Circuit 7402 quad 2-input NOR	6	U3,6,9, U18,23,24	01295	SN7402N,J
6	480949	Integrated Circuit 7451 dual 2-wide 2-input	1	U30	01295	SN7451N OR J
7	475676	Integrated Circuit 74123 dual retrig monosta	1	U33	01295	SN74123N,J
8	472463	Integrated Circuit 7474 dual D edge-trig flip-flop	1	U35	01295	SN7474N,J
9	472462	Integrated Circuit	1	U4	01295	SN74H73N,J
10	479068	Integrated Circuit 7493 4-bit binary counter	1	U5	01295	SN7493AN
11	471951	Integrated Circuit 7490 decade counter	1	U7	01295	SN7490AN,AJ
12	535002-0002	Integrated Circuit 74393 dual 4-bit binary counter	1	U2	01295	SN74393N
13	372115-0007	Crystal Unit, quartz, 8 MHz	1	Y1	30149	CR-18A/U(MOD)
14	198660	Socket	1		91506	8000-AG10-1
15	475323	Retainer, capstan	2	6-4/3		

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 16 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	539754	Harness, control logic	1	6-4/4	14028	
2	19785-0022	Lamps, general 28.0 volt midget f1	A/R		05464	327
3	19544-0553	Setscrew, cup point 1/4-28 x 1/4 stl blk cad	2	6-4/8	56878	
4	249108-0001	Nut, speed push on olive drab	2	6-4/14	78553	C185-014-1
5	250466-0036	Spring, helical, ext and comp, music wire	1	6-4/15	84830	LC-014B-7 MUSIC WIRE
6	472467-0006	Knob, indicator	1	6-4/17	14028	
7	376402-0003	Panel Lamp Assembly	4	6-4/20	32539	L-28/40
8	475227-0005	Switch, rotary poles 1 pos 10	1	6-4/21	14028	
9	475240-1101	Switch, pushbutton SPDT momentary	1	6-4/23	87034	53-54580-135+51650-703327
10	475240-1102	Switch, pushbutton SPDT momentary	1	6-4/24	87034	53-54580-135+51650-704327
11	475240-1103	Switch, pushbutton SPDT momentary	1	6-4/25	87034	53-54580-135+51650-705327
12	475240-1104	Switch, pushbutton SPDT momentary	1	6-4/26	87034	53-54580-135+51650-706327
13	475240-1106	Switch, pushbutton SPDT momentary	1	6-4/27	87034	53-54580-135+51650-708327

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 17 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	475240-1107	Switch, pushbutton SPDT momentary	1	6-4/28	87034	53-54580-135+51650-841327
2	532141-0001	Capstan and Reel Servo	1	6-1/8,6-7	14028	
3	475234	Extractor 0.25 dimension	2	6-7/3	18677	S-202
4	157742-0003	Heat Sink, radial fin	1	6-7/4	74370	3AL-635-2R
5	7138-1515	Res, fixed, composition 150 ohm ±5%, 1/2 W	2	R106,107		RCR20G151JS
6	7138-2215	Res, fixed, composition 220 ohm ±5%, 1/2 W	1	R2		RCR20G221JS
7	7138-5115	Res, fixed, composition 510 ohm ±5%, 1/2 W	1	R95		RCR20G511JS
8	7140-4315	Res, fixed, composition 430 ohm ±5%, 2.0 W	2	R78,98		RCR42G431JS
9	70025-0369	Res, fixed, wirewound 47.0 ohm ±3%, 3 W	1	R45	91637	TYPE RS2B
10	70083-3055	Res, fixed, composition 3.00 megohm ±5%, 1/4 W	1	R38		RCR07G305JS
11	471922-1012	Res, fixed, metal oxide 100 ohm ±2%, 1/4 W	12	R4,7,43, R47,49, R76,96, R99,100, R101,102, R108	24546	C4-100 OHM 2 PCT
12	471922-1022	Res, fixed, metal oxide 1K ohm ±2%, 1/4 W	6	R24,66, R68,86, R94,14	24546	C4-1K OHM 2 PCT

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 18 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
				6-7		
1	471922-1032	Res, fixed, metal oxide 10K ohm ±2%, 1/4 W	14	R25,46, R31,32, R48,50, R67,77, R97,89, R34,35, R91,93	24546	C4-10K OHM 2 PCT
2	471922-1042	Res, fixed, metal oxide 100K ohm ±2%, 1/4 W	1	R27	24546	C4-100K OHM 2 PCT
3	471922-1222	Res, fixed, metal oxide 1.2K ohm ±2%, 1/4 W	1	R29	24546	C4-1200 OHM 2 PCT
4	471922-1512	Res, fixed, metal oxide 150 ohm ±2%, 1/4 W	1	R30	24546	C4-150 OHM 2 PCT
5	471922-1522	Res, fixed, metal oxide 1.5K ohm ±2%, 1/4 W	2	R52,69	24546	C4-1500 OHM 2 PCT
6	471922-1532	Res, fixed, metal oxide 15K ohm ±2%, 1/4 W	2	R59,79	24546	C4-15K OHM 2 PCT
7	471922-1812	Res, fixed, metal oxide 180 ohm ±2%, 1/4 W	2	R87,88	24546	C4-180 OHM 2 PCT
8	471922-1842	Res, fixed, metal oxide 180K ohm ±2%, 1/4 W	1	R33	24546	C4-180K OHM 2 PCT
9	471922-2022	Res, fixed, metal oxide 2K ohm ±2%, 1/4 W	4	R90,92, R104,103	24546	C4-2K OHM 2 PCT
10	471922-2032	Res, fixed, metal oxide 20K ohm ±2%, 1/4 W	1	R36	24546	C4-20K OHM 2 PCT
11	471922-2222	Res, fixed, metal oxide 2.2K ohm ±2%, 1/4 W	4	R16,17, R18,19	24546	C4-2200 OHM 2 PCT
12	471922-3042	Res, fixed, metal oxide 300K ohm ±2%, 1/4 W	2	R63,83	24546	C4-300K OHM 2 PCT

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 19 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
				6-7		
1	471922-3312	Res, fixed, metal oxide 330 ohm ±2%, 1/4 W	1	R1	24546	C4-330 OHM 2 PCT
2	471922-4712	Res, fixed, metal oxide 470 ohm ±2%, 1/4 W	2	R57,74	24546	C4-470 OHM 2 PCT
3	471922-4722	Res, fixed, metal oxide 4.7K ohm ±2%, 1/4 W	10	R3,10,11, R20 thru R23,28, R62,82	24546	C4-4.7K OHM 2 PCT
4	471922-4732	Res, fixed, metal oxide 47K ohm ±2%, 1/4 W	6	R12,13, R15,26, R58,75	24546	C4-47K OHM 2 PCT
5	471922-5112	Res, fixed, metal oxide 510 ohm ±2%, 1/4 W	1	R42	24546	C4-510 OHM 2 PCT
6	471922-5122	Res, fixed, metal oxide 5.1K ohm ±2%, 1/4 W	8	R60,61, R64,65, R80,81, R84,85	24546	C4-5.1K OHM 2 PCT
7	471922-6232	Res, fixed, metal oxide 62K ohm ±2%, 1/4 W	2	R39,40	24546	C4-62K OHM 2 PCT
8	471922-6812	Res, fixed, metal oxide 680 ohm ±2%, 1/4 W	4	R5,6,8, R9	24546	C4-680 OHM 2 PCT
9	471922-7512	Res, fixed, metal oxide 750 ohm ±2%, 1/4 W	2	R44,105	24546	C4-750 OHM 2 PCT
10	378770-0007	Res, var, metal oxide 1K ohm ±10%, 3/4 W	2	R53,70	80294	3009P-1-102
11	378770-0010	Res, var, metal oxide 10K ohm ±10%, 3/4 W	1	R37	80294	3009P-1-103
12	378770-0012	Res, var, metal oxide 50K ohm ±10%, 3/4 W	1	R41	80294	3009P-1-503

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 20 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
				6-7		
1	70094-0031	Cap, fixed, mica 150 pF ±5%, 500 Vdc	1	C9	93790	CD15F151J03-500WV
2	70094-0042	Cap, fixed, mica 390 pF ±5%, 500 Vdc	1	C11	93790	CD15F391J03-500WV
3	95222-0033	Cap, fixed, alum elect 20.0 uF +75 -10%, 6 Vdc	2	C38,44		
4	95222-0044	Cap, fixed, alum elect 250.0 uF +75 -10%, 6 Vdc	2	C21,22	14655	NLW250-6
5	215095-0162	Cap, fixed, mylar 0.0015 uF ±10%, 200 V	3	C8,12,55	56289	192P15292
6	215095-0492	Cap, fixed, mylar 0.1 uF ±10%, 80 V	5	C23,33, C52,53, C54	56289	192P1049R8
7	215095-0552	Cap, fixed, mylar 0.0047 uF ±10%, 80 V	1	C18	56289	192P4729R8
8	215095-0592	Cap, fixed, mylar 0.01 uF ±10%, 80 V	1	C24	56289	192P1039R8
9	215095-0622	Cap, fixed, mylar 0.022 uF ±10%, 80 V	2	C19,35	56289	192P2239R8
10	374986-0121	Cap, fixed, tantalum 0.68 uF ±20%, 20 Vdc	1	C30	31433	T310A684M020AS
11	471863-0002	Cap, fixed, tantalum 22.0 uF ±20%, 10 Vdc	1	C27	31433	T320B226-M10AS
12	471863-0006	Cap, fixed, tantalum 2.2 uF ±20%, 25 Vdc	2	C14,15	31433	T320A225-M25AS
13	471863-0007	Cap, fixed, tantalum 1.2 uF ±20%, 35 Vdc	2	C16,17	31433	T320A125-M35AS

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 21 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
				6-7		
1	471863-0008	Cap, fixed, tantalum 0.1 uF ±20%, 35 Vdc	18	C2,3,4, C5,25, C26,28, C29,31, C32,36, C37,39, C40,42, C43,45, C46	31433	T320A104-M35AS
2	471930-0003	Cap, fixed, electrolytic 100 uF -10 +75%, 16 V	9	C1,6,7, C20,41, C47,48, C50,51	14655	NLW 100-16
3	471930-0006	Cap, fixed, electrolytic 100 uF -10 +75%, 25 V	1	C34	14655	NLW 100-25
4	70094-0027	Cap, fixed, mica 100 pF ±5%, 500 Vdc	2	C10,13	93790	CD15F101J03-500WV
5	215472-0023	Semiconductor Device, diode 1N754A, 6.8 V	1	VR4	04713	1N754A
6	378979-0008	Diode, zener 6.2 V ±5%	1	VR3	04713	1N4735A
7	378979-0015	Diode, zener 12 V ±5%	4	VR1,2,5, VR6	04713	1N4742A
8	246954	Diode Signal Switching 25 V work volt, 1N4154	12	CR1,2,3, CR7,10 thru CR16	03508	1N4154
9	471934	Integrated Circuit 7400 quad 2-input NAND	9	U5,7,8, U11,12, U13,16, U22,25	01295	SN7400N,J

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 22 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
				6-7		
1	471936	Integrated Circuit 7410 triple 3-input NAND	1	U10	01295	SN7410N,J
2	471939	Integrated Circuit 7402 quad 2-input NOR	1	U19	01295	SN7402N,J
3	471940	Integrated Circuit 7405 hex inverter open C	3	U14,15, U18	01295	SN7405N,J
4	471941	Integrated Circuit 7404 hex inverter	2	U6,9	01295	SN7404N,J
5	471950	Integrated Circuit 7473 dual J-K flip-flop	2	U17,20	01295	SN7473N,J
6	471957	Integrated Circuit 741C operational amplifier	7	U1,2,3, U4,21, U23,24	07263	UA741TC
7	204749-1002	Jack, tip horizontal pc red	1	TP2	83330	430-102
8	204749-1003	Jack, tip horizontal pc black	1	TP10	83330	430-103
9	204749-1004	Jack, tip horizontal pc dk green	1	TP5	83330	430-104
10	204749-1006	Jack, tip horizontal pc orange	1	TP3	83330	430-106
11	204749-1007	Jack, tip horizontal pc yellow	1	TP4	83330	430-107
12	204749-1008	Jack, tip horizontal pc brown	1	TP1	83330	430-108
13	204749-1010	Jack, tip horizontal pc blue	1	TP6	83330	430-105
14	246014-0001	Transistor, NPN, power 2N3053	5	Q7,8,9, Q11,14	86684	2N3053

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 23 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	471472	Transistor, NPN 2N3947	7	6-7 Q1,2,3, Q4,5, Q10,15	04713	2N3947
2	471927	Transistor, NPN 2N2219	2	Q12,13	04713	2N2219
3	471931	Transistor, PNP 2N3251	1	Q6	04713	2N3251N,J
4	475697	Inductor	1	L1		
5	531432	Plate, connector mounting	1	6-1/41	14028	
6	532880-0018	Meter, elapsed time 18.0 Vdc	1	6-1/M1	27780	H500-18 VDC, BLK PLASTIC
7	519408	Post, guide	2	6-1/43	14028	
8	531703	Component Mounting Assembly	1	6-1/9	14028	
9	531701	Plate, mounting capstan motor components	1		14028	
10	371763-1402	Board, terminal, barrier section 14-sngl sldr lug	1	TB1	07859	33014
11	197593-0006	Socket, relay wire clip for 2 pole soc	1		02288	30040-1
12	197593-0007	Socket, relay 2 pole socket	1		02288	30055-1
13	247804-0001	Socket, power transistor	1		22753	PTS-1
14	248422-0001	Insulator, transistor mounting	1		08289	DM-101 OR DM-103-SL

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 24 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	248422-0007	Insulator, transistor mounting	3		08289	MW-750-195
2	248422-0009	Insulator, transistor mounting	3		78189	4706-05-02-CAD PLATE
3	248422-0012	Insulator, transistor mounting TO-3/TO-66	2		08289	TW-150-193-100
4	70018-5083	Res, fixed, wirewound 0.50 ohm ±3%, 50 W	1	R1	91637	RH50-G-R50-H
5	246014-0003	Transistor, NPN, power 2N3055	1	Q2	86684	2N3055
6	251304-0002	Cap, fixed, electrolytic 1000 uF +75 -10%, 25 Vdc	1	C1	56289	39D108G025GL4
7	372295-0002	Diode, rectifier 1.0A 200 V, 1N4003	1	CR1	04713	1N4003
8	475222	Transistor MJE3055	2	Q1,4	04713	MJE3055
9	475223	Transistor	1	Q3		
10	476404-2024	Relay, armature, enclosed 24 Vdc	1	K1	02288	TF-154 C-C 24 VDC
11	541218	Harness, transport	1	6-1/7	14028	
12	362914-0222	Cable, special purpose, electrical, 2 cond AWG 22 wht/blk	2		12814	EXE-22-1934-(2)STJ
13	204902-0006	Contact, electrical connector wire range 20-22-24	26		81312	100-51020S
14	204902-0005	Contact, electrical connector wire range 16-18-20	25		81312	100-51016S

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 25 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	204902-0004	Contact, electrical connector wire range 14-16-18	18		81312	100-51014S
2	378989-4011	Key, polarizing, elec conn crimp, 22-18 AWG wire	19		00779	60215-4
3	9774-0068	Terminal, lug, solderless, insul, 18-22 AWG stud size 2	37		14726	SS22504
4	158617-0012	Terminal, lug, quick disconnect, yel for 0.250 x 0.032 tab	19		14726	S09302ST1
5	158617-0011	Terminal, lug, quick disconnect, red for 0.250 x 0.032 tab	4		14726	S09620ST1
6	158617-0013	Terminal, lug, quick disconnect, red for 0.187 x 0.020 tab	6		14726	S09624ST1
7	9774-0003	Terminal, lug, solderless, insul, 18-22 AWG stud size 6	4			MS25036-101
8	9774-0062	Terminal, lug, solderless, insul, 18-22 AWG stud size 2	4		00779	324158
9	70104-0216	Cable, shielded, electrical AWG 16-2 conductor	2		08547	
10	525534-0080	Cable, teflon, insul 18 AWG wht/blk twist pair	5		14028	
11	519550-0099	Key, polarizing	4		81312	109-9892
12	532990	Bracket, connector	1		14028	

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 26 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	538006	Bracket, connector mounting preamplifier	2		14028	
2	169811-0004	Cable, shielded 2 conductor, AWG 24	50		17217	G12A100
3	9774-0006	Terminal, lug, solderless, insul, 14-16 AWG stud size 8	2			MS25036-153
4	204902-0008	Contact, electrical connector wire range 24-26-28	65		81312	100-51024S
5	804612-0001	Cable, electrical, single conduc	5		17217	2419ET-SFSDJ
6	525534-0009	Cable, teflon, insul 22 AWG wht/blk twist pair	2			
7	126716-0316	Cable, rf, coaxial RG-316/U	3		23172	QPL-17
8	205299-0001	Connector, electrical receptacle without hood	2	A2J23, A3J23	81312	XAC75SFG2010ES151-1A
9	372889-0001	Connector, electrical 44 pins	2	A2J22A, A2J22B	81312	SRE-44-P-N
10	378989-0909	Connector, pc board receptacle, 9 positions natural	3	A1J8, A1J9, A1J10	00779	582383-9
11	379674-0101	Connector, receptacle	2	A1J4, A1J5	05574	2VD36D/1-1
12	479065-0013	Connector, receptacle, elect 41 sockets	1	A1J7		MS3122E20-41S

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 27 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	519550-0010	Connector, electrical solder tabs	4	A2J10, A2J21, A3J20, A3J21	81312	HSD10S0
2	800477-0007	Connector, rectangular	1	A2J24	81312	JF3S-1P-ACD
3	48192	Connector, recp, twist lock,	1	6-1/A1J2	74545	7486
4	519278-0001	Power Supply Assembly 60 Hz AC	1	6-1/16	14028	
5	522130-0100	Power Supply, 60 Hz input optional selection spec	1			
6	518847	Bracket, filter	2			
7	519269	Filter Assembly	1		14028	
8	518848	Frame, filter	1			
9	518948	Retainer, filter	1			
10	476105-0001	Filter, air 4.87 x 4.30	1			
11	473120	Bracket	1	6-1/45		
12	379335-0001	Tape Tension Sensor, 1/2 in. takeup (See Separate Parts List)	1	6-1/23,6-3	14028	
13	379335-0002	Tape Tension Sensor, 1/2 in. supply (See Separate Parts List)	1	6-1/22,6-3	14028	

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 28 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	379335-0003	Tape Tension Sensor, 1 in. takeup (See Separate Parts List)	1	6-1/21,6-3	14028	
2	379335-0004	Tape Tension Sensor, 1 in. supply (See Separate Parts List)	1	6-1/20,6-3	14028	
3	536450	Case Assembly, amplifier, 1/2 in.	1	6-1/2,6-10	14028	
4	536450	Case Assembly, amplifier, 1 in.	2		14028	
5	536451	Case Assembly, amplifier	1	6-10/1	14028	
6	379576-0001	Bracket, guide	1	6-10/2	14027	
7	379576-0002	Bracket, guide	1	6-10/3	14028	
8	475375	Shield	1	6-10/4	14028	
9	379604	Guide, pc card	34	6-10/5	14028	
10	536452	Mother Board and Harness Assy	1	6-10/6	14028	
11	539920-0001	Mother Board Assembly, amplifier case	1	6-10/10, 6-11	14028	
12	70094-3051	Cap, fixed, mica 820 pF ±10%, 300 Vdc	3	C10 thru C12	93790	CD15F821K03-300WV
13	475606-1000	Jumper, wire	1		14028	
14	202790-0018	Cap, fixed, ceramic 0.01 uF ±20%, 100 Vdc	9	C1 thru C9	56289	TG-S10
15	372295-0002	Diode, rectifier 1.0A 200 V, 1N4003	4	CR1 thru CR4	04713	1N4003
16	471472	Transistor, NPN 2N3947	1	Q1	04713	2N3947

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 29 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
				6-11		
1	471922-1022	Res, fixed, metal oxide 1K ohm ±2%, 1/4 W	2	R10,11	24546	C4-1K OHM 2 PCT
2	471922-3922	Res, fixed, metal oxide 3.9K ohm ±2%, 1/4 W	9	R1 thru R9	24546	C4-3900 OHM 2 PCT
3	472460-0501	Relay, reed type 1 form A	2	K11,15	15636	RA30381051
4	472460-0502	Relay, reed type 2 form A	5	K10,12,13, K14,16	15636	RA30382051
5	475225-0019	Connector, printed circuit 19 positions	17	J1A thru J7A,J1B thru J7B, J8,9,10	00779	3-583486-2
6	480625-0503	Relay, reed 5 Vdc 200 ohm coil 1 PDT	9	K1 thru K9	15636	RA3044-1051
7	536453	Harness, amplifier case	1	6-10/14	14028	
8	205299-0002	Connector, electrical plug with side entry hood	1	A2P23	81312	XAC75PCG1400ES151-1B
9	204902-0001	Contact, electrical connector wire range 14-16-18	1		81312	100-1014P
10	204902-0002	Contact, electrical connector wire range 16-18-20	4		81312	100-1016P
11	204902-0003	Contact, electrical connector wire range 20-22-24	33		81312	100-1020P

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 30 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	126716-0316	Cable, rf, coaxial RG-316/U	4	6-10	23172	QPL-17
2	204902-0007	Contact, electrical connector wire range 24-26-28	34		81312	100-1024P
3	525534-0080	Cable, teflon insulated 18 AWG twisted pair	4		14028	
4	525534-0009	Cable, teflon insulated 22 AWG twisted pair	2		14028	
5	473313-0002	Head Mount Assembly, 1/2 in.	1		14028	
6	473313-0005	Head Mount Assembly, 1 in.	1		14028	
7	535561-0002	Roller, tape guide, 1/2 in.	4	6-1/5	14028	
8	526859-0002	Roller, ball bearing, 1/2 in.	1		25504	RC3536
9	521902-0001	Shim, tape guide	2		14028	
10	521902-0002	Shim, tape guide	2		14028	
11	521902-0003	Shim, tape guide	1		14028	
12	521902-0004	Shim, tape guide	1		14028	
13	521902-0005	Shim, tape guide	1		14028	
14	547414	Cable Assembly, LED footage counter	1	6-1/46	14028	
15	471872	Connector, receptacle, electrical	1	6-1/47,A1J11	95238	K600-128-28XA
16	474635	Key, polarizing	2	6-1/48	95238	602-23 TYPE K

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 31 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	535561-0005	Roller, tape guide, 1 in.	4	6-1/4	14028	
2	526859-0005	Roller, ball bearing, 1 in.	1		25504	RC3482
3	521902-0001	Shim, tape guide	2		14028	
4	521902-0002	Shim, tape guide	2		14028	
5	521902-0003	Shim, tape guide	1		14028	
6	521902-0004	Shim, tape guide	1		14028	
7	521902-0005	Shim, tape guide	1		14028	
8	212541-0002	Reel Hub, 1/2 in.	2	6-1/25	14028	
9	212541-0005	Reel Hub, 1 in.	2	6-1/24	14028	
10	536150	Shield Assembly, head	1	6-1/3	14028	
11	539748	Panel, control	1	6-1/42	14028	
12	527189-0001	Cover and Window Assembly	1	6-1/13	14028	
13	532710	Cover Assembly, dust	1	6-1/6	14028	
14	526293	Cover, transport plate	1	6-1/14	14028	
15	534647	Panel, side, right	1	6-1/32	14028	
16	534646	Panel, side, left	1	6-1/33	14028	
17	476161	Damper Roller Assembly, 1 in.	1	6-1/19		
18	476162	Damper Roller Assembly, 1/2 in.	1	6-1/18		
19	533945	Cable Assembly, extender	1		14028	
20	475618-0001	Card, extender, servo	1		14028	
21	379634-0001	Card, extender, amplifier	1		14028	
22	476103-0002	Panel, blank, amplifier	1	6-1/44	14028	
23	475347-0002	Module Assembly, blank	1		14028	

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 32 of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	479190-0003	Preamplifier, 1/2 in.	2	6-1/17,6-9		
2	479190-0003	Preamplifier, 1 in.	4			
3	475606-0500	Jumper, wire, preformed	1		14028	
4	471922-3012	Res, fixed, metal oxide 300 ohm ±2%, 1/4 W	8	R10 thru R17	24546	C4-300 OHM 2 PCT
5	471922-5102	Res, fixed, metal oxide 51 ohm ±2%, 1/4 W	8	R1 thru R8	24546	C4-51 OHM 2 PCT
6	471863-0004	Cap, fixed, tantalum 10.0 uF ±20%, 20 Vdc	2	C1,2	31433	T320B106-M20AS
7	252501-0004	Transistor, PNP type 2N3906-5	8	Q1,2,7, Q8,13, Q14,19, Q20	01295	2N3906-5
8	364752	Transistor, NPN	8	Q3,4,9. Q10,15, Q16,21, Q22	04713	2N5089
9	471931	Transistor, PNP 2N3251	8	Q5,6, Q11,12, Q17,18, Q23,24	04713	2N3251
10	472466-0046	Inductor, fixed, shielded 1000 uH ±5%	2	L1,2	76493	9250-105-5 PCT
11	525788-0001	Component network 12-446	4	U1,2,3,4	14028	

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 32A of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	547418	LED Footage Counter Control Board	1	6-1/49,6-15	14028	
2	547419	Printed Wiring Board	1	6-15/1	14028	
3	547921	Battery, dry 4.5 Vdc	1	B1	87334	DP16-3-48
4	521520-0011	Semiconductor Device, diode	8	CR1 thru CR8	81350	JAN1N4148
5	479699-1049	Cap, ceramic 0.100 uF ±20%, 50 Vdc	3	C1,2,16	81349	CKO5BX104M
6	479699-1061	Cap, ceramic 1 uF ±20%, 50 Vdc	5	C3,4,8,9, C10	81349	CKO6BX105M
7	479699-1033	Cap, ceramic 4700 pF ±20%, 100 Vdc	1	C5	81349	CKO5BX472M
8	479699-1025	Cap, ceramic 1K pF ±20%, 200 Vdc	1	C6	81349	CKO5BX102M
9	479699-0021	Cap, ceramic 470 pF ±10%, 200 Vdc	1	C7	81349	CKO5BX471K
10	479699-1037	Cap, ceramic 0.01 uF ±20%, 100 Vdc	4	C11,12, C13,15	81349	CKO5BX103M
11	70143-0440	Cap, fixed, tantalum 100 uF ±20%, 10 Vdc	1	C14	81349	M39003/01-2262
12	365834-0002	Transistor, NPN	1	Q1	01295	2N3904
13	471922-2022	Res, fixed, metal oxide 2K ohm ±2%, 1/4 W	19	R1,2, R6 thru 9, R11,20, R21,23, R31 thru 34, R36,43 thru R46	24546	C4-2K OHM-2PCT

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 32B of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	471922-1022	Res, fixed, metal oxide 1K ohm ±2%, 1/4 W	4	R3,4,41, R42	24546	C4-1K OHM-2PCT
2	471922-2212	Res, fixed, metal oxide 220 ohm ±2%, 1/4 W	1	R5	24546	C4-220 OHM-2PCT
3	471922-3922	Res, fixed, metal oxide 3.9K ohm ±2%, 1/4 W	1	R10	24546	C4-3900 OHM-2PCT
4	471922-5122	Res, fixed, metal oxide 5.1K ohm ±2%, 1/4 W	3	R12,37,38	24546	C4-5.1K OHM-2PCT
5	471922-1132	Res, fixed, metal oxide 11K ohm ±2%, 1/4 W	1	R13	24546	C4-11K OHM-2PCT
6	471922-5112	Res, fixed, metal oxide 510 ohm ±2%, 1/4 W	3	R14,18,19	24546	C4-510 OHM-2PCT
7	471922-1042	Res, fixed, metal oxide 100K ohm ±2%, 1/4 W	1	R15	24546	C4-100K OHM-2PCT
8	471922-1522	Res, fixed, metal oxide 1.5K ohm ±2%, 1/4 W	4	R16,17, R24,48	24546	C4-1500 OHM-2PCT
9	471922-2032	Res, fixed, metal oxide 20K ohm ±2%, 1/4 W	4	R22,29, R30,40	24546	C4-20K OHM-2PCT
10	471922-6812	Res, fixed, metal oxide 680 ohm ±2%, 1/4 W	1	R25	24546	C4-680 OHM-2PCT
11	471922-3022	Res, fixed, metal oxide 3K ohm ±2%, 1/4 W	1	R26	24546	C4-3000 OHM-2PCT
12	471922-1532	Res, fixed, metal oxide 15K ohm ±2%, 1/4 W	1	R27	24546	C4-15K OHM-2PCT
13	471922-4322	Res, fixed, metal oxide 4.3K ohm ±2%, 1/4 W	1	R28	24546	C4-4.3K OHM-2PCT

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 32C of 33)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	471922-1012	Res, fixed, metal oxide 100 ohm ±2%, 1/4 W	1	R35	24546	C4-100 OHM-2PCT
2	471922-6222	Res, fixed, metal oxide 6.2K ohm ±2%, 1/4 W	1	R39	24546	C4-6200 OHM-2PCT
3	471922-3032	Res, fixed, metal oxide 30K ohm ±2%, 1/4 W	1	R47	24546	C4-30K OHM-2PCT
4	471922-9112	Res, fixed, metal oxide 910 ohm ±2%, 1/4 W	1	R49	24546	C4-910 OHM-2PCT
5	471934	Integrated Circuit	3	U1,24,32	01295	SN7400N
6	532402	Integrated Circuit	2	U2,3	02735	CD4089BF
7	534116	Integrated Circuit	2	U4,18	02735	CD4093BE
8	475695	Integrated Circuit	2	U5,31	01295	SN7417N
9	520001	Integrated Circuit	1	U6	27014	LM339N
10	525051	Integrated Circuit	4	U7,8,10, U12	02735	CD4029AE
11	480356	Integrated Circuit	2	U9,27	01295	SN7406N
12	533352	Integrated Circuit, CMOS	1	U11	02735	CD4013BE
13	538545-0001	Integrated Circuit	2	U13,20	01295	SN75121N
14	526857	Integrated Circuit	3	U14,17,22	27014	MM74C902N
15	480341-1022	Component Network 1.0K ohm, 8 term res	1	U15	73138	898-3-R-1.0K
16	526854	Integrated Circuit	1	U16	50088	MK50395N
17	522151	Integrated Circuit	1	U19	02735	CD40406AD

Table 6-1. Parts List for the 4020 Tape Transport (Sheet 33 of 33)

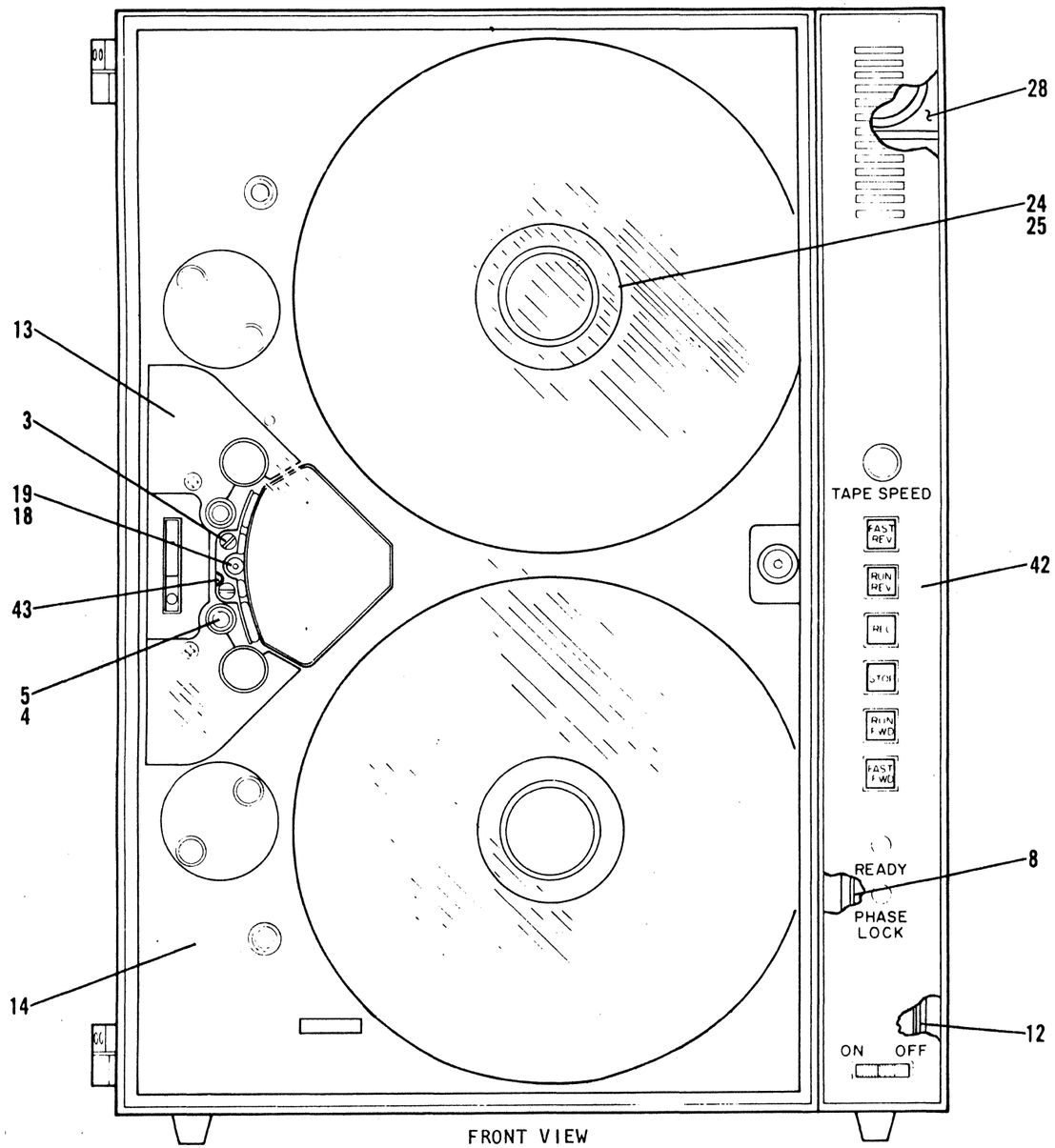
ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	547800	Integrated Circuit	2	U21,26	02735	CD4021BE
2	547799	Integrated Circuit	1	U23	31471	S5101LP
3	527834	Integrated Circuit	1	U25	02735	CD4078BD
4	479686-4722	Component Network, dual-in-line, 4.7K ohm	1	U28	73138	898-1-R-4.7K
5	527146-0012	Integrated Circuit	1	U29	27014	LM340T-12
6	479686-1032	Component Network, dual-in-line 10K ohm, 15 pullup res	1	U30	73138	898-1-R-10.0K
7	547439	Insulator, IC	1	6-15/58	14028	
8	377698-0003	Socket, IC, 16 contacts	2	6-15/59	91506	516-AG10D
9	475606-0300	Jumper, wire, preformed	2	6-15/60	07168	475606-0300
10	475606-0600	Jumper, wire, preformed	1	6-15/61	07168	475606-0600
11	154101-1044	Screw, machine, 100 deg flat hd, 4-40 x 3/8, cres	1	6-15/64	96906	MS24693-C4
12	70077-0252	Washer, flat size 4, cres	1	6-15/65	96906	MS15795-803
13	166497-2020	Washer, split lock size 4, med steel, cad pl	1	6-15/66	96906	MS35338-40
14	7074-0244	Nut, plain, hex 4-40, steel, cad plate	1	6-15/67	96906	MS35649-242

Table 6-2. Parts List for the Tape Tension Sensor (Sheet 1 of 2)

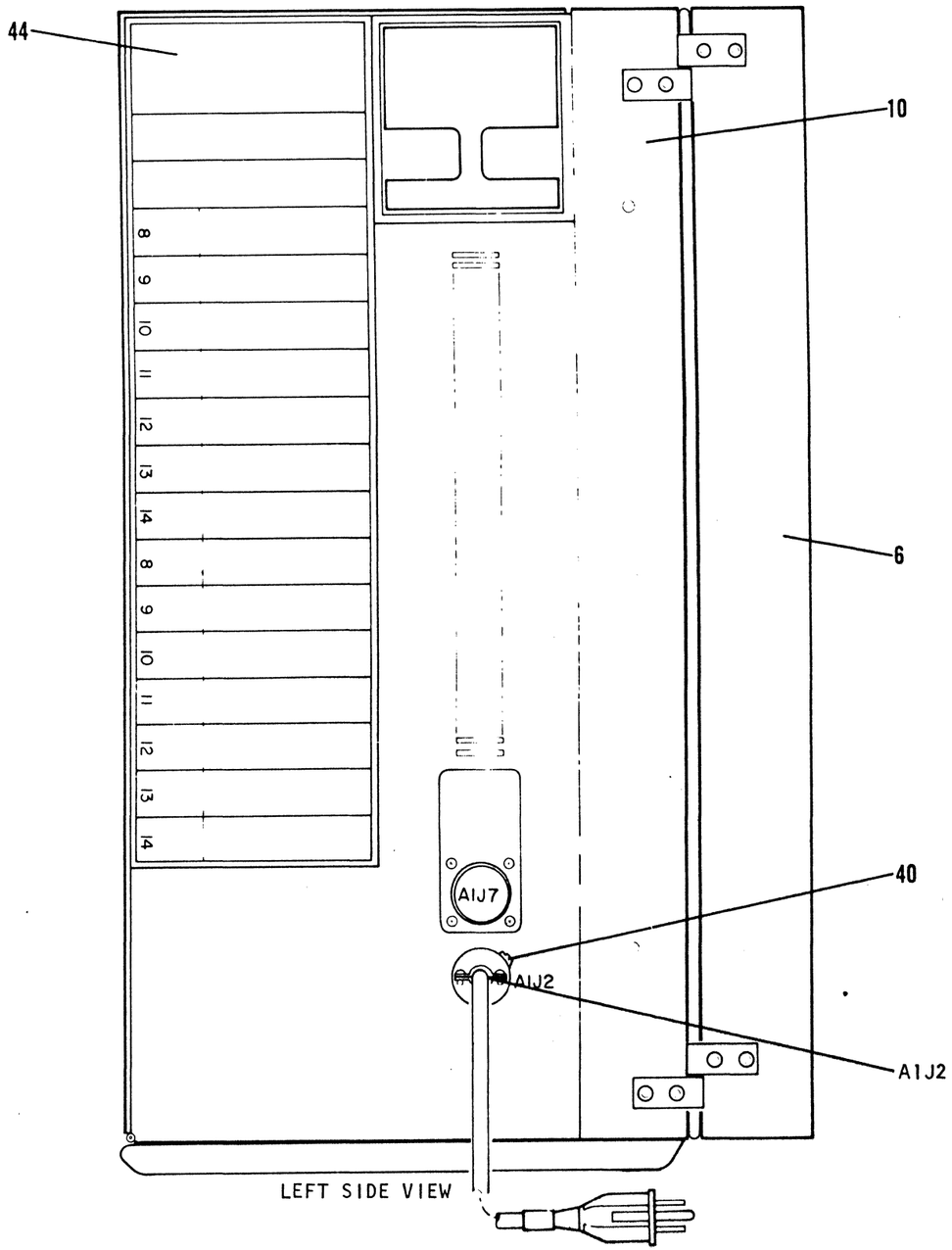
ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY -1	QTY -2	QTY -3	QTY -4	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	379335-0001	Tape Tension Sensor, 1/2 in. takeup	1				6-3	14028	
2	379335-0002	Tape Tension Sensor, 1/2 in. supply		1				14028	
3	379335-0003	Tape Tension Sensor, 1 in. takeup			1			14028	
4	379335-0004	Tape Tension Sensor, 1 in. supply				1		14028	
5	379334	Housing, machined, tension sensor	1	1	1	1	1	14028	
6	253605-0005	Bearing	2	2	2	2	2		
7	379535-0001	Shaft and Hub Assembly	1		1		3		
8	379535-0003	Shaft and Hub Assembly		1		1	4		
9	379326	Bearing, tape guide	2	2	2	2	5		
10	379529	Plate, support	1	1	1	1	6	14028	
11	379538	Spring, torsion, 1/2 in.	1	1			7		
12	379632	Spring, torsion, 1 in.			1	1	7		
13	70095-0080	Pin, straight, headless	1	1	1	1	8	08547	
14	379530-0001	Disk Assembly, variable density		1		1	9	14028	
15	379530-0002	Disk Assembly, variable density	1		1		10	14028	
16	21891-0007	Ring, retaining, external 0.250 D.	1	1	1	1	13	79136	MS16624-1025
17	379534	Knob, spring adjust	1	1	1	1	14		
18	379533	Clamp, spring adjust knob	1	1	1	1	15		

Table 6-2. Parts List for the Tape Tension Sensor (Sheet 2 of 2)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5 6	QTY -1	QTY -2	QTY -3	QTY -4	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
							6-3		
1	476137-0001	Sensor Assembly, light	1		1		17	14028	
2	19544-0205	Setscrew, cup point 6-32 x 3/8	2	2	2	2	19	56878	
3	379542	Bumper, rubber	2	2	2	2	21		
4	19544-0101	Setscrew, cup point 4-40 x 1/8	2	2	2	2	22	56878	
5	476135	Cover, tension sensor	1	1	1	1	26		
6	476137-0002	Sensor Assembly, light		1		1	29	14028	
7	83878-0536	Setscrew, full dog point 2-56 x 0.25	2	2	2	2	31		
8	476136	Switch, actuator	1	1	1	1	32		
9	19544-0301	Setscrew, cup point 8-32 x 1/8	1	1	1	1	33	56878	
10	518197	Switch, sensitive, SPDT	1	1	1	1	43	19635	E-63-76HA REF



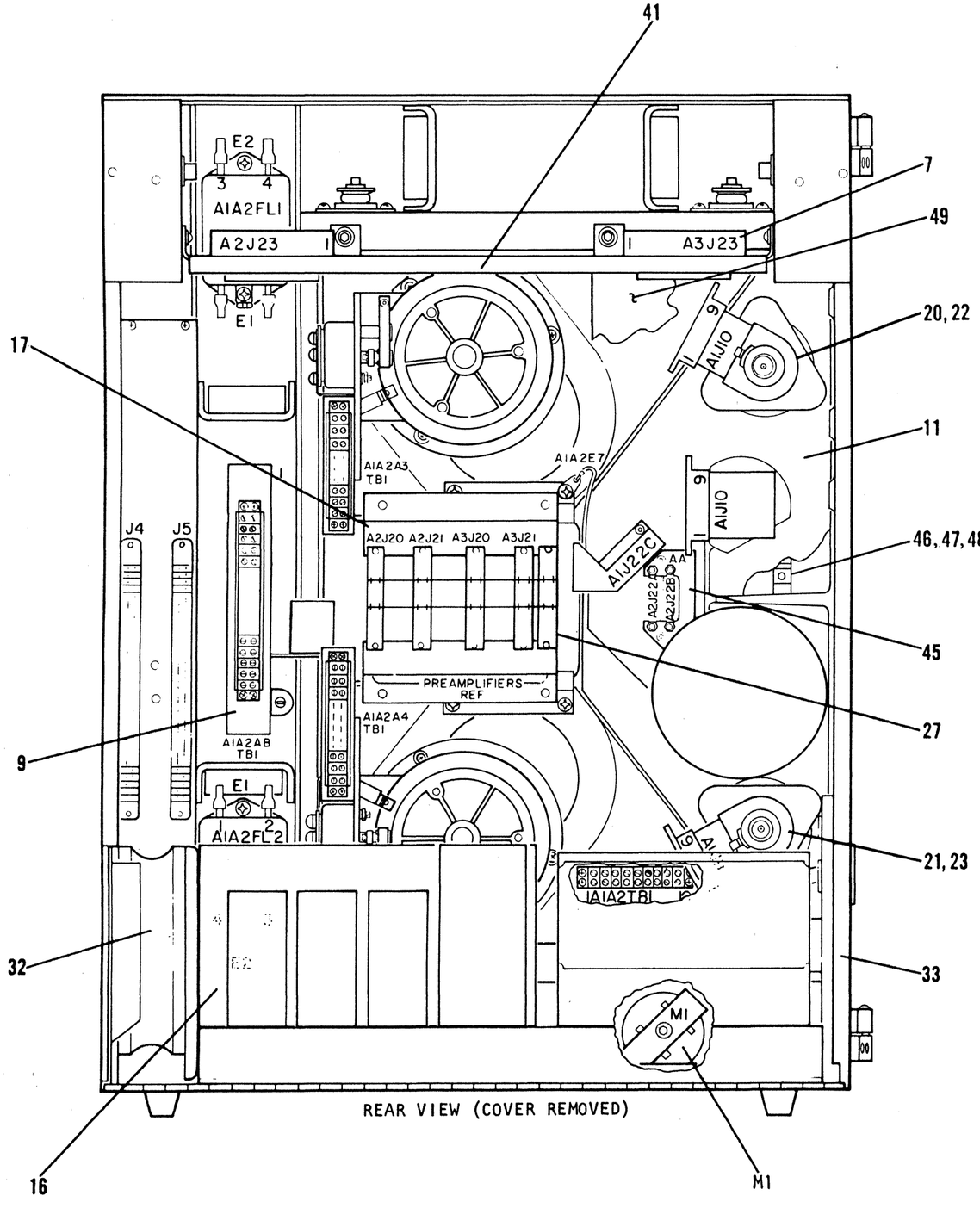
FRONT VIEW

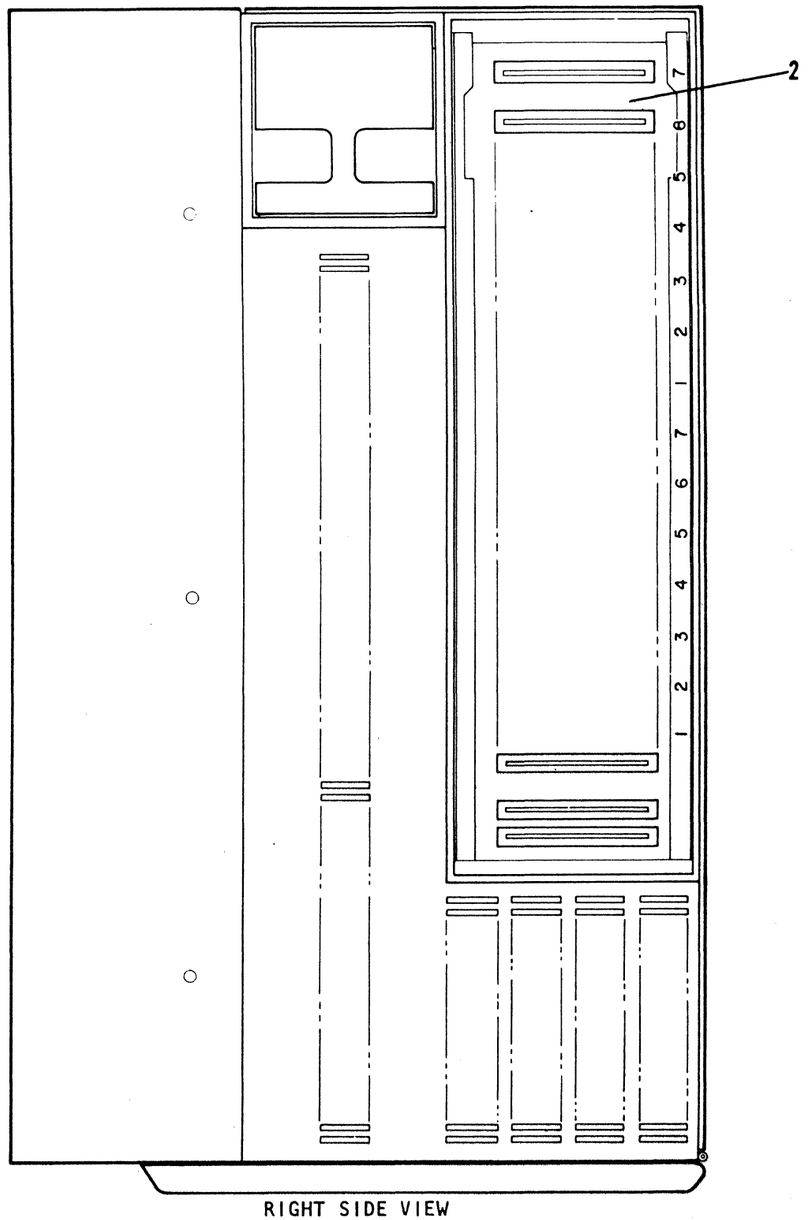


LEFT SIDE VIEW

D-541200-D (REF)

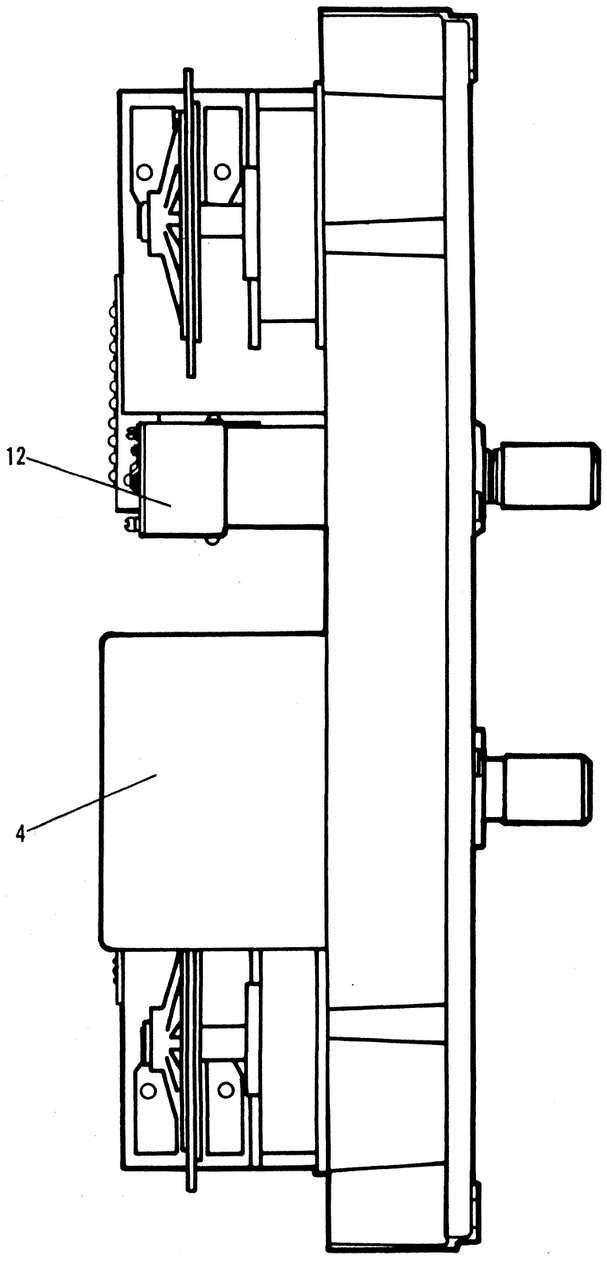
Figure 6-1. Tape Transport Assembly (Sheet 1 of 2)

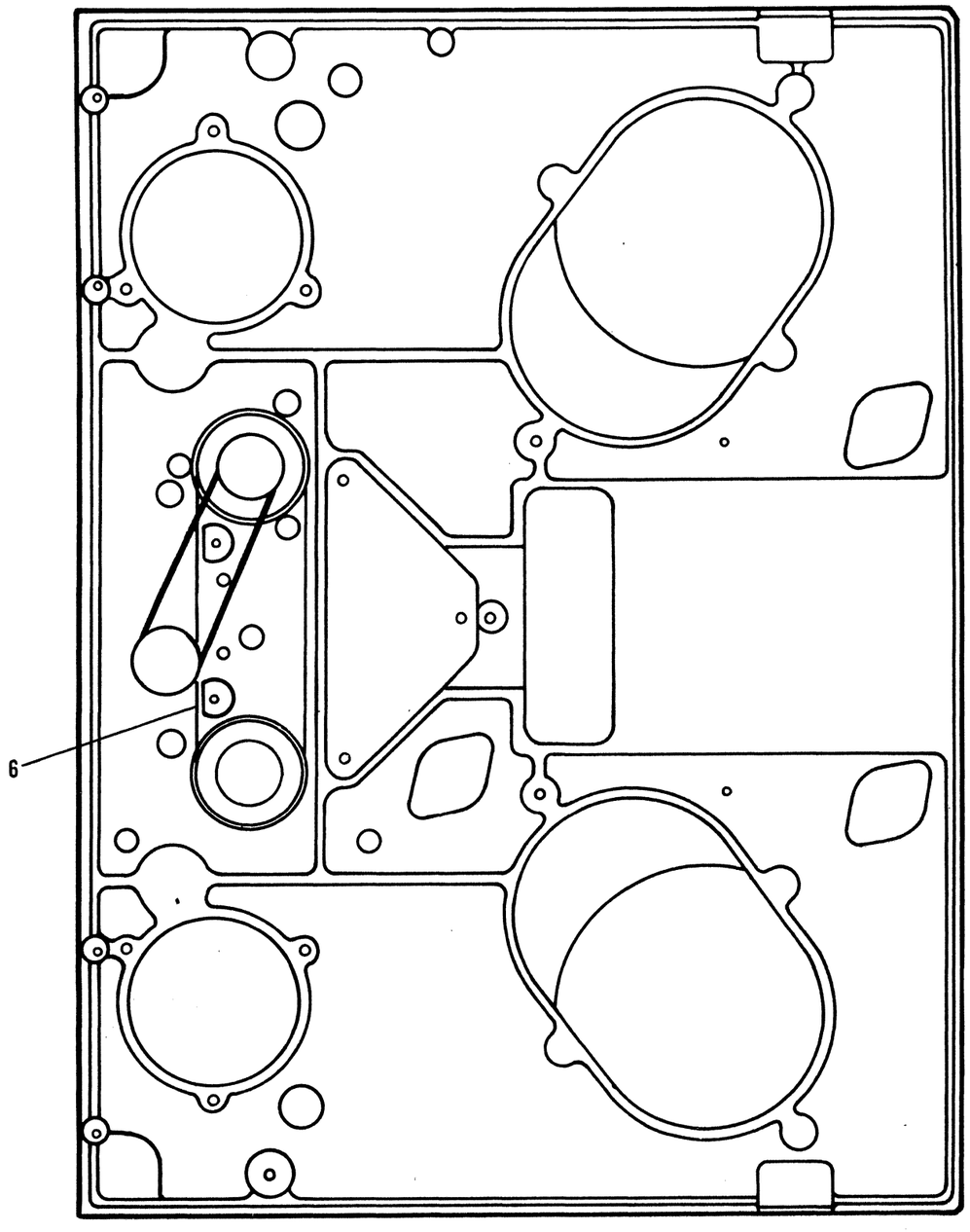




D-541200-D (REF)

Figure 6-1. Tape Transport Assembly (Sheet 2 of 2)





4. REFERENCE SCHEMATIC J-526202.

3.

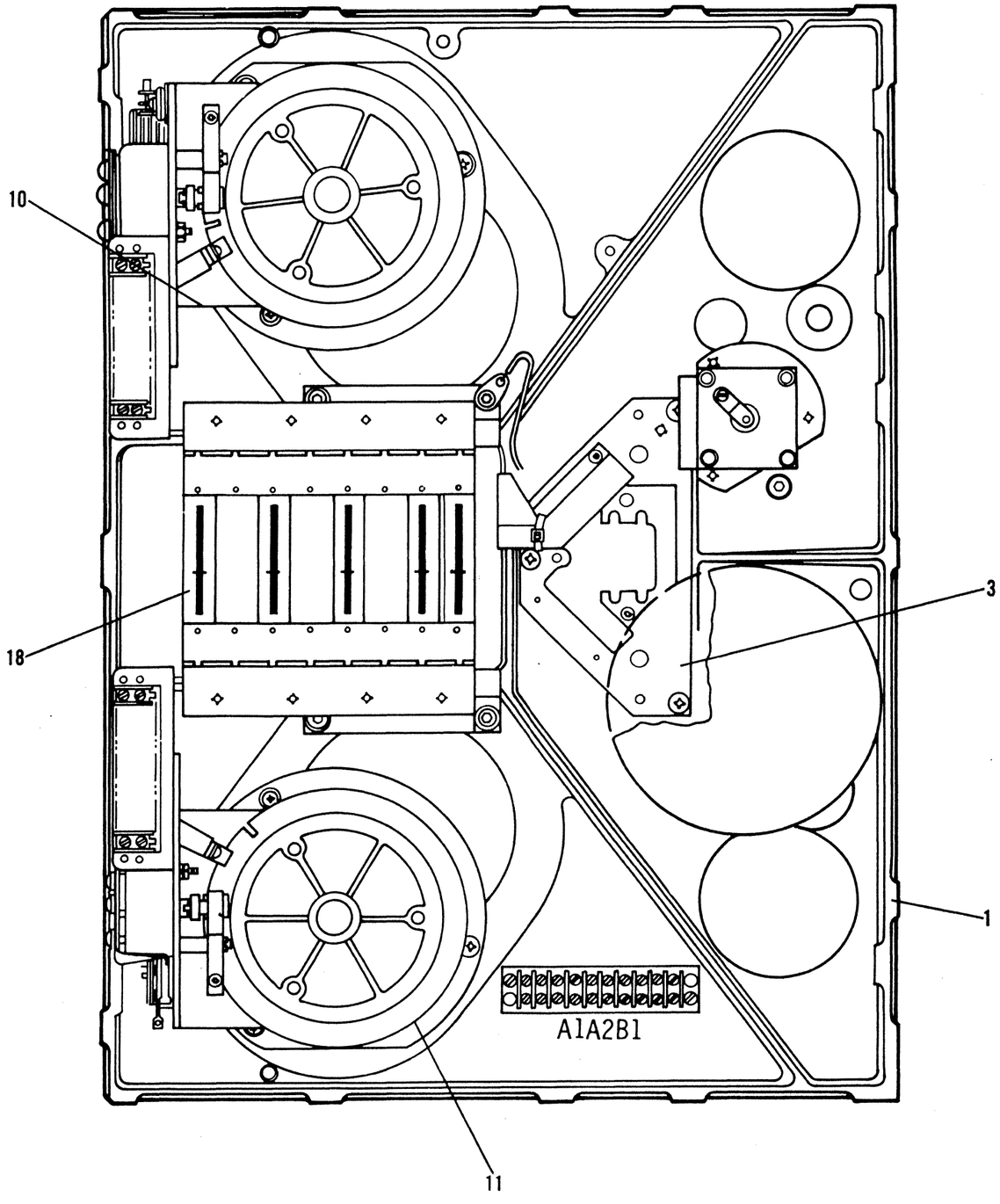
2. SIMILAR TO E-479561.

⟨1⟩ MOUNTING SURFACES OF REEL MOTOR ASSEMBLY AND MATING SURFACE OF TRANSPORT TO BE CLEAN AND FREE OF FOREIGN MATTER THAT MIGHT EFFECT THE PERPENDICULARITY OF THE MOTORS.

NOTES: UNLESS OTHERWISE SPECIFIED.

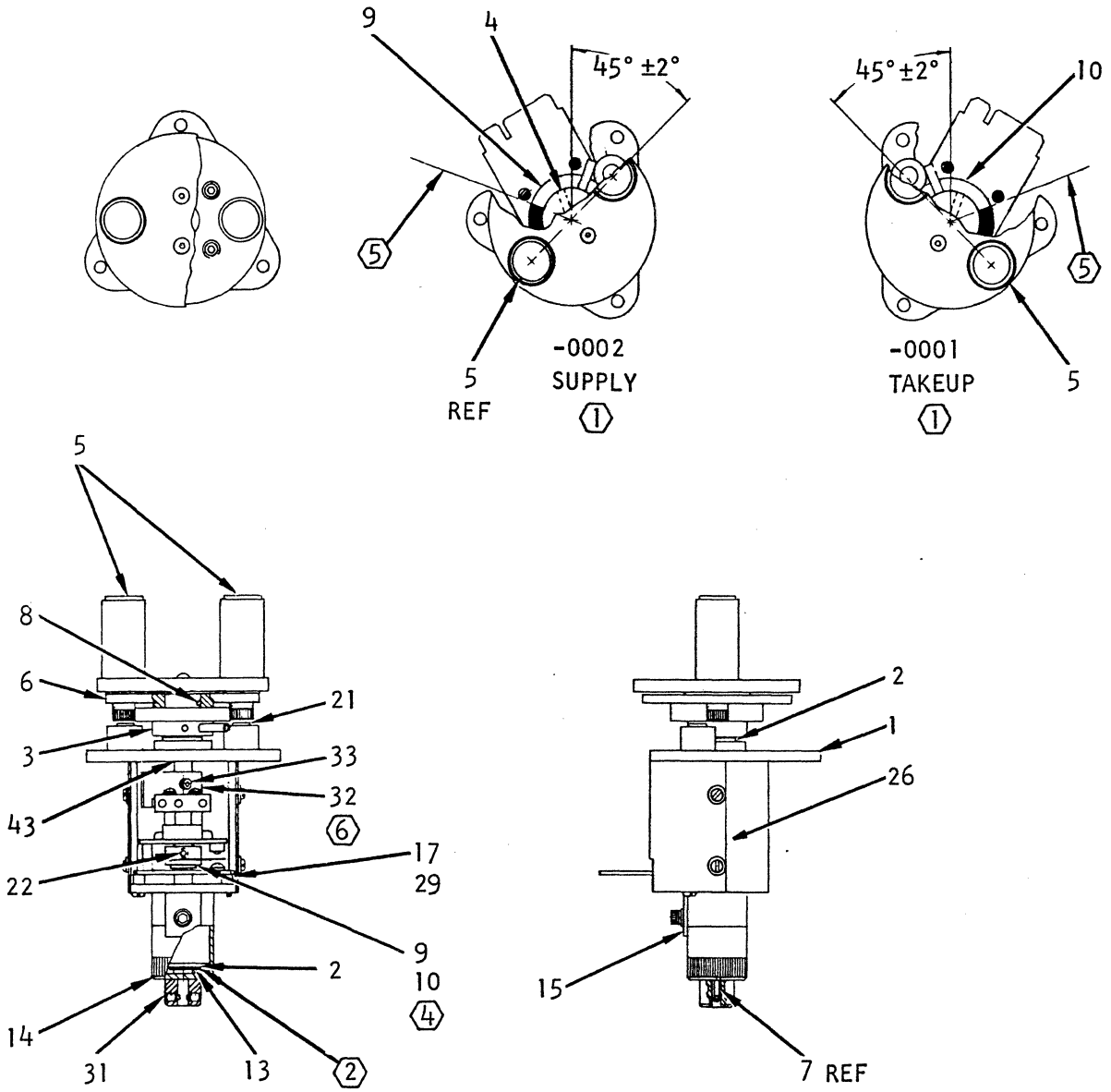
D-529852-B (REF)

Figure 6-2. Tape Transport Mounting Plate Assembly (Sheet 1 of 2)



D-529852-B (REF)

Figure 6-2. Tape Transport Mounting Plate Assembly (Sheet 2 of 2)



6 ADJUST ITEM 32 (ACTUATOR) TO ACTUATE TO OPEN WHEN SENSOR IS IN POSITION SHOWN. -0001 SHOWN, -0002 OPPOSITE.

5 ALIGN ITEM 9 OR 10 (DISC) TO PC CARD SPACER AS SHOWN.

4 ADJUST ITEM 9 OR 10 WITH DISC CENTERED BETWEEN PHOTO XSTR & LED ON LIGHT SENSOR ASSY, ITEM 17 OR 29.

3.

2 ASSEMBLE ENOUGH SHIMS TO COMPRESS SPRING ONE HALF OF ITS FREE HEIGHT.

1 THESE VIEWS SHOW THE ORIENTATION OF THE DISC ASSEMBLIES, ITEMS 9 & 10, THE STOP PIN, ITEM 11, AND THE TAPE GUIDE ROLLERS, ITEM 5, TO EACH OTHER PRIOR TO INSTALLATION INTO THE NEXT ASSEMBLY.

NOTES: UNLESS OTHERWISE SPECIFIED.

D-379335-L (REF)

Figure 6-3. Tape Tension Sensor Assembly

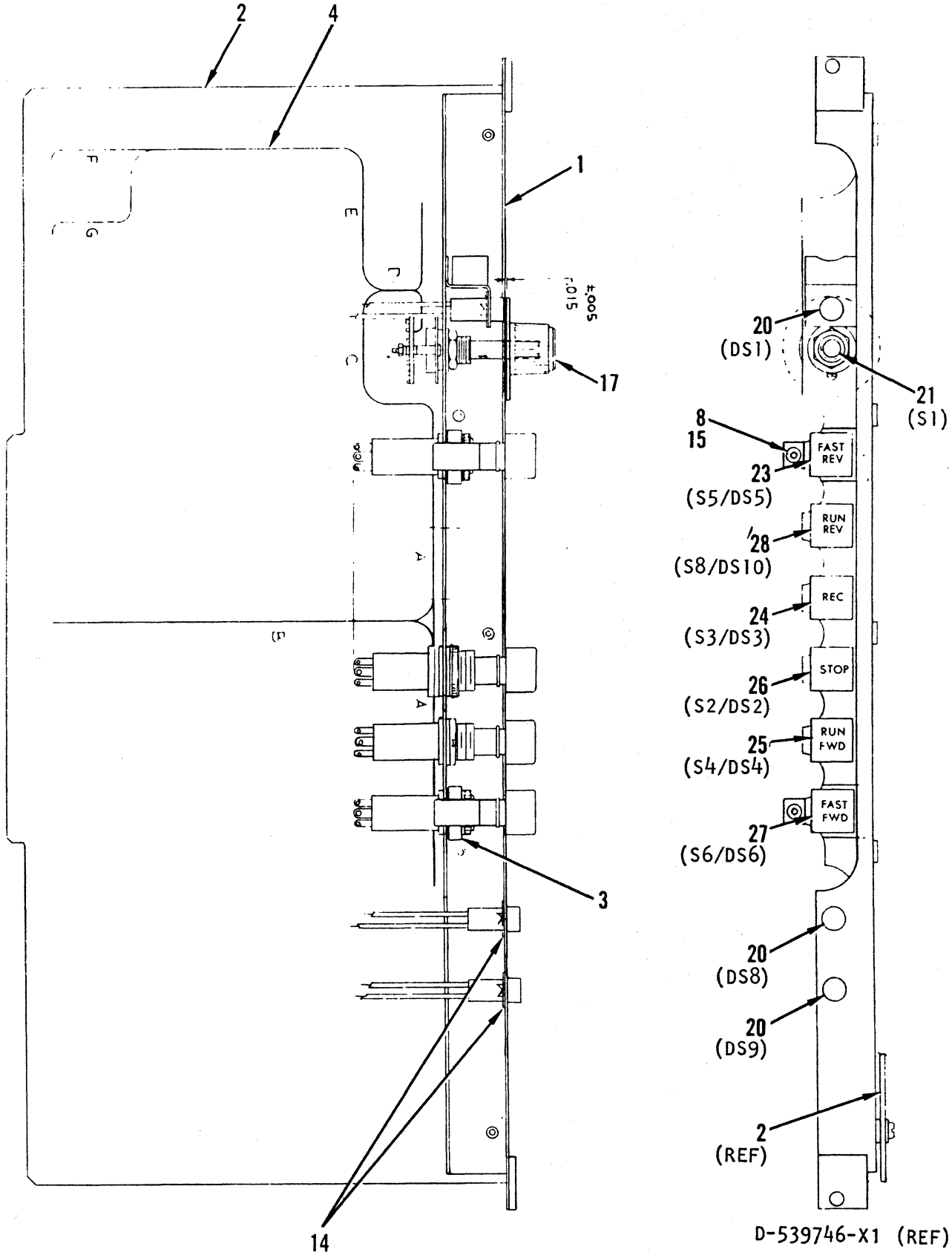
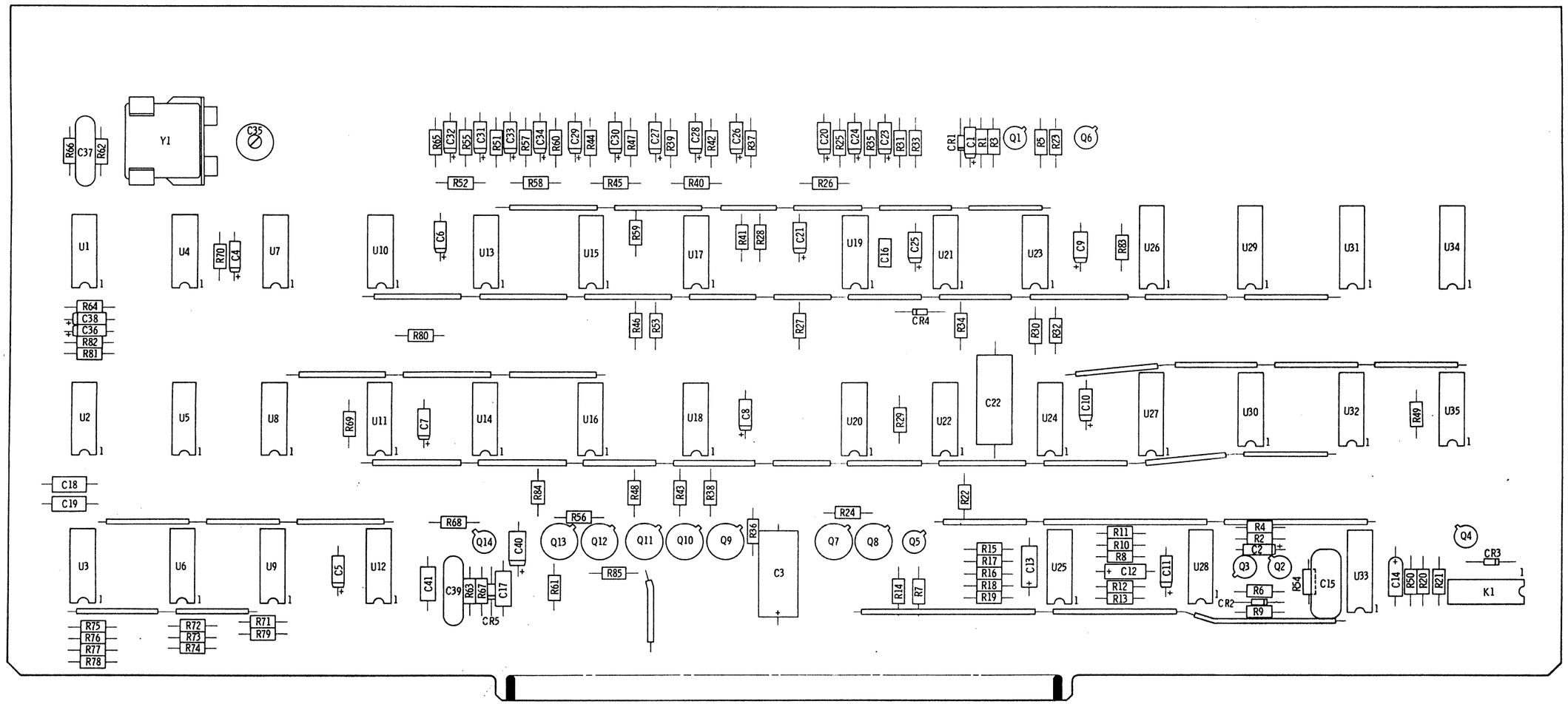
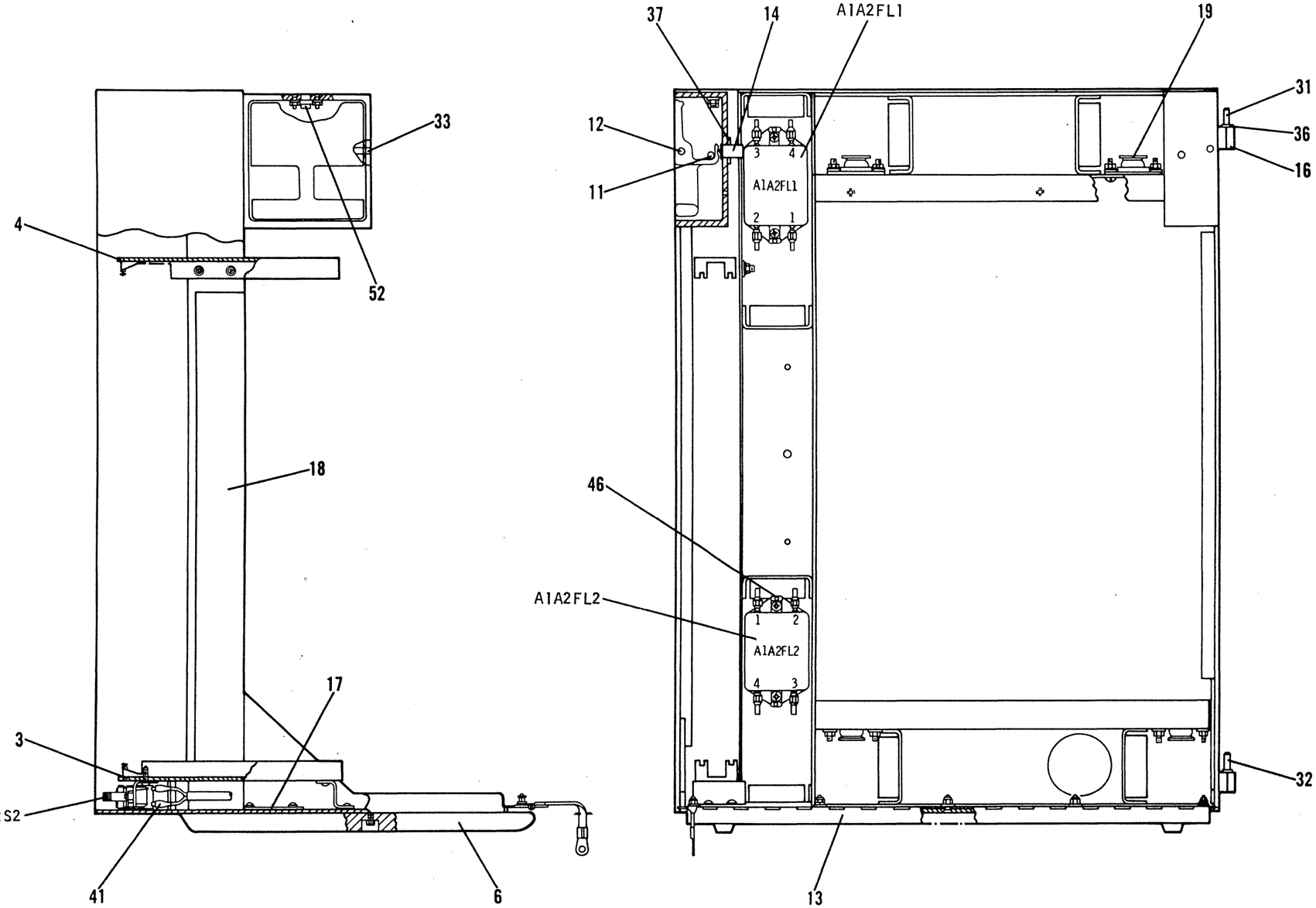


Figure 6-4. Control Logic and Bracket Assembly



E-539755-X3 (REF)

Figure 6-5. Control Logic Circuit Card

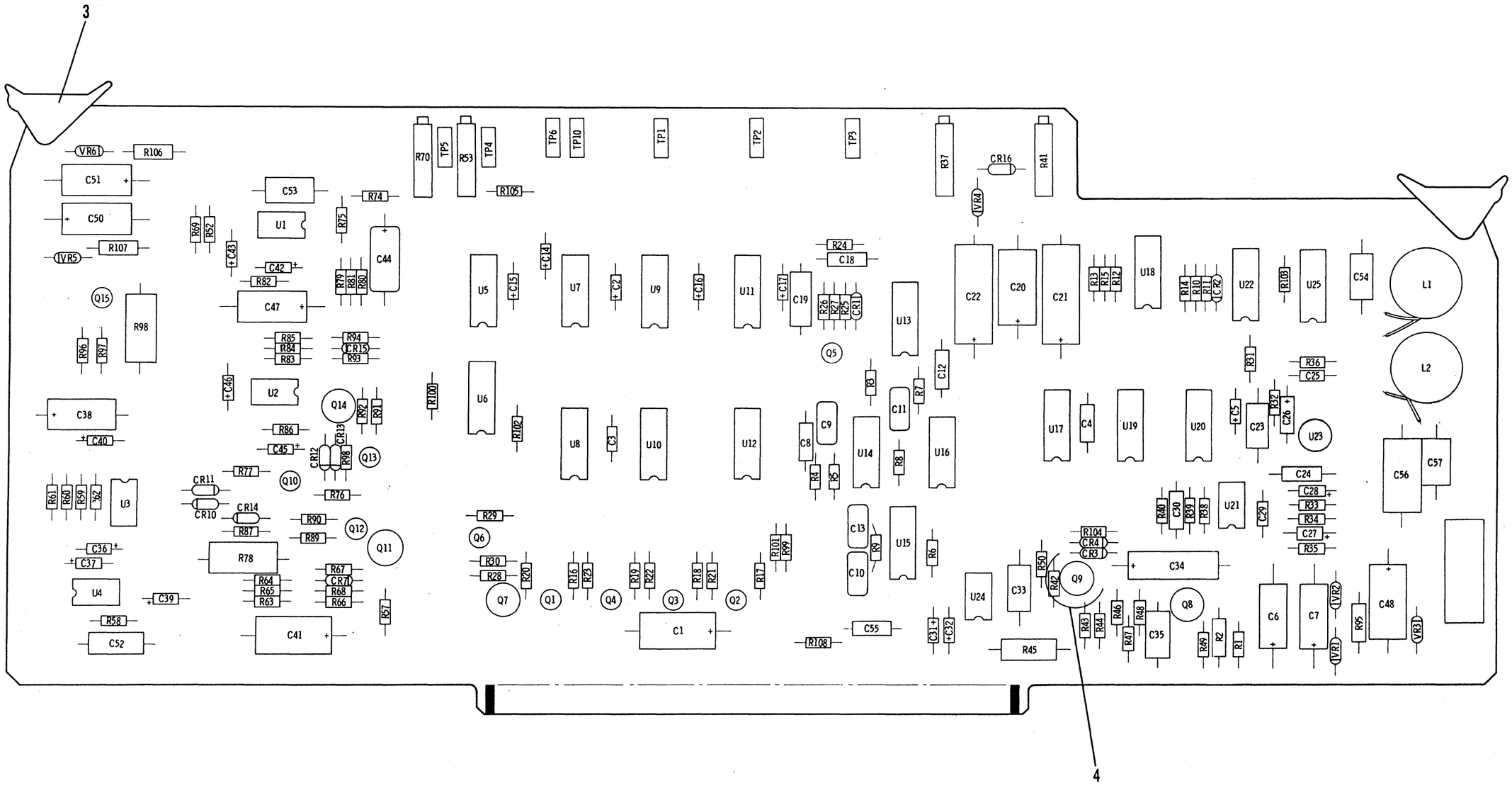


1. IDENTIFY COMPONENT INFORMATION AS REQUIRED PER MIL-STD-130.

NOTES: UNLESS OTHERWISE SPECIFIED.

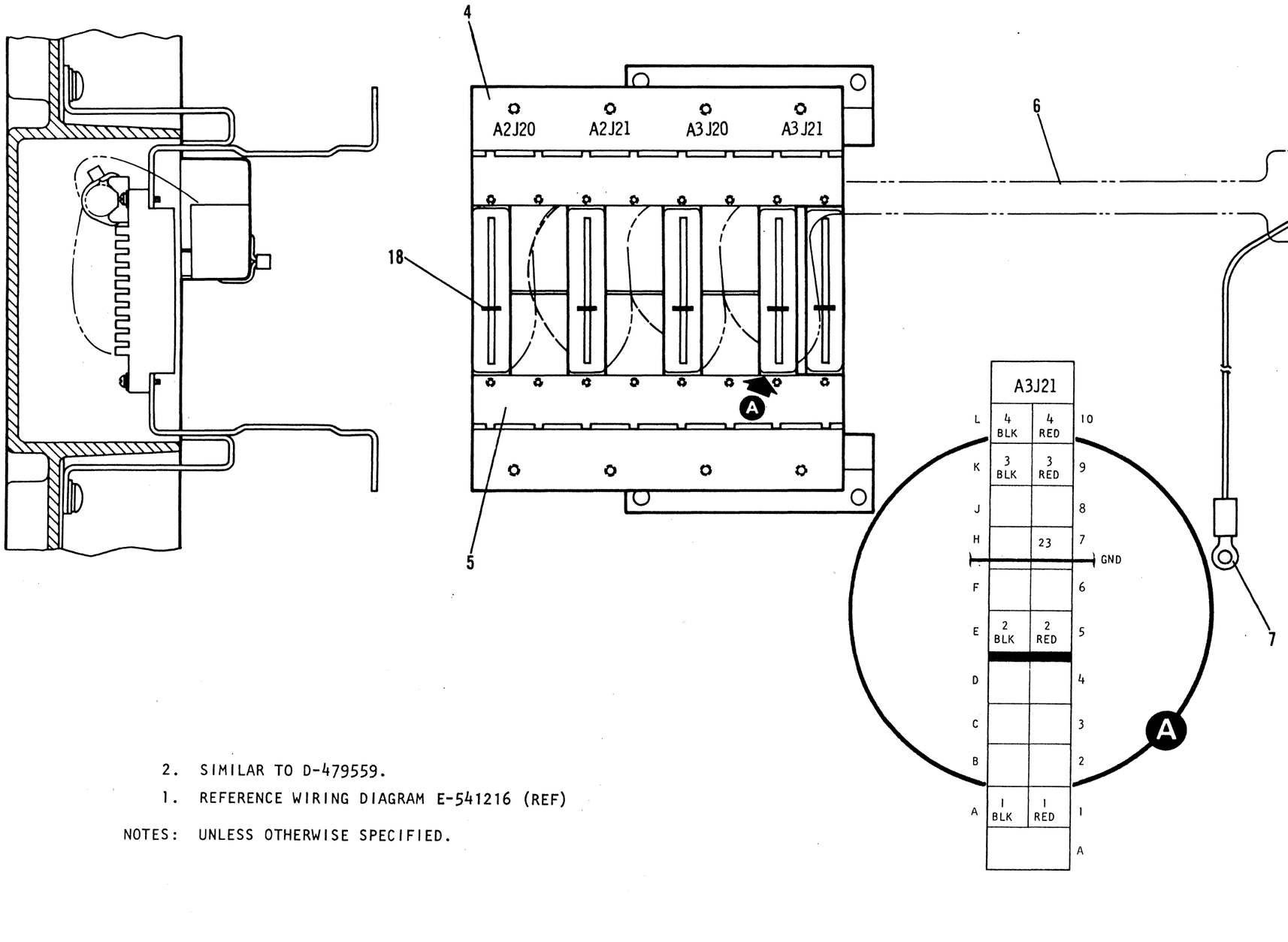
D-536461-B (REF)

Figure 6-6. Transport and Frame Assembly



E-532141-A (REF)

Figure 6-7. Capstan and Reel Servo Circuit Card

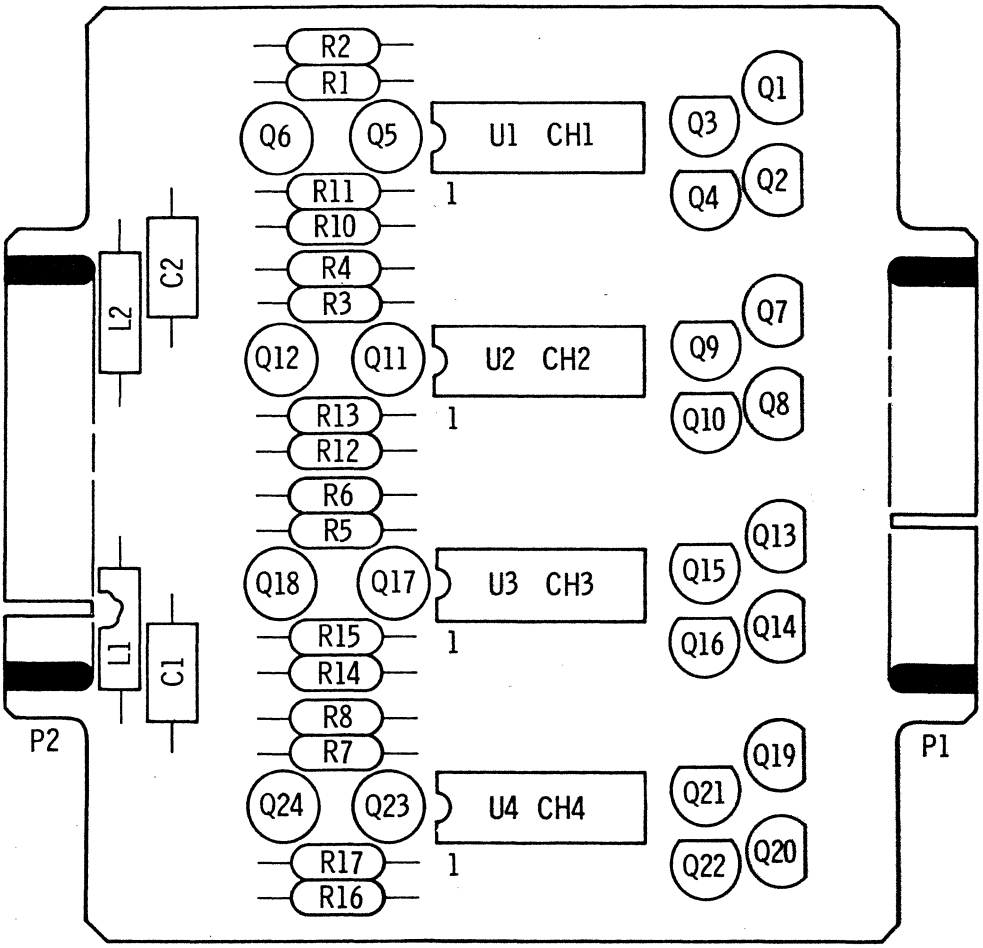


2. SIMILAR TO D-479559.
1. REFERENCE WIRING DIAGRAM E-541216 (REF)

NOTES: UNLESS OTHERWISE SPECIFIED.

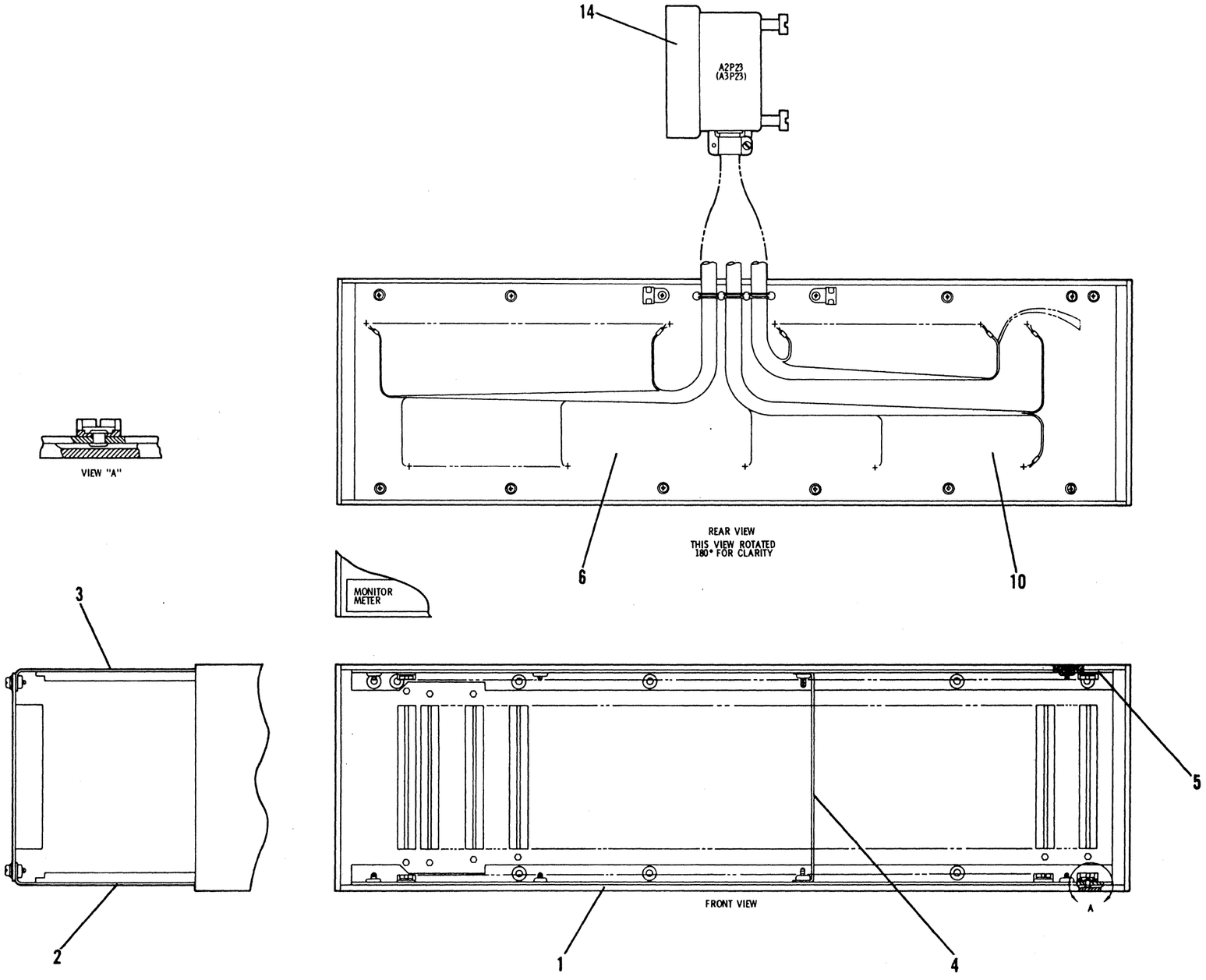
D-541217-B (REF)

Figure 6-8. Preamplifier Housing Assembly



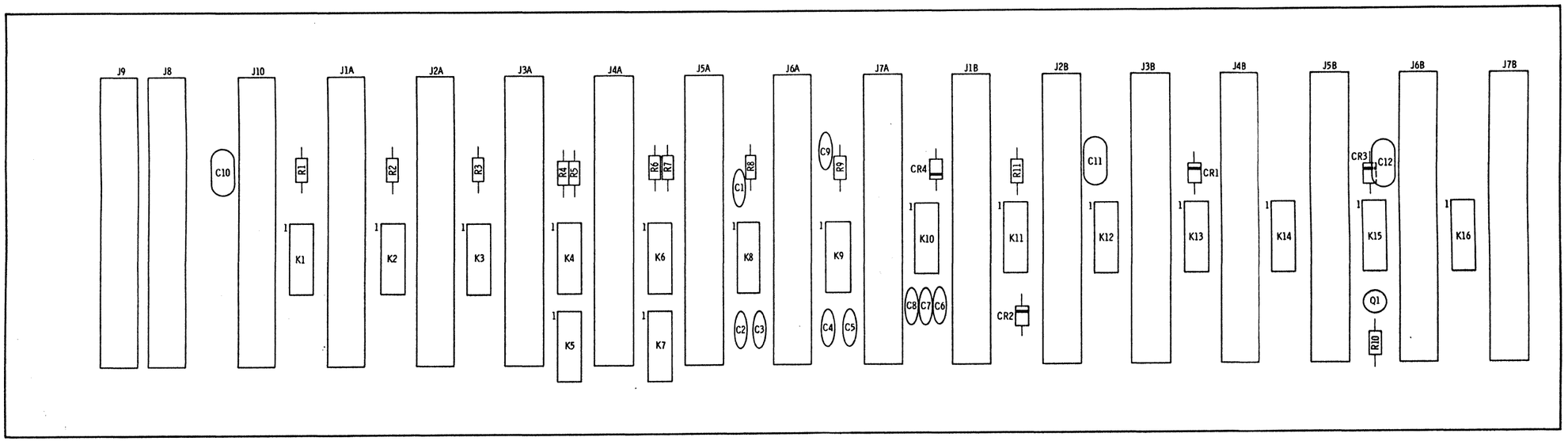
D-479190-J (REF)

Figure 6-9. Preamplifier Assembly Board



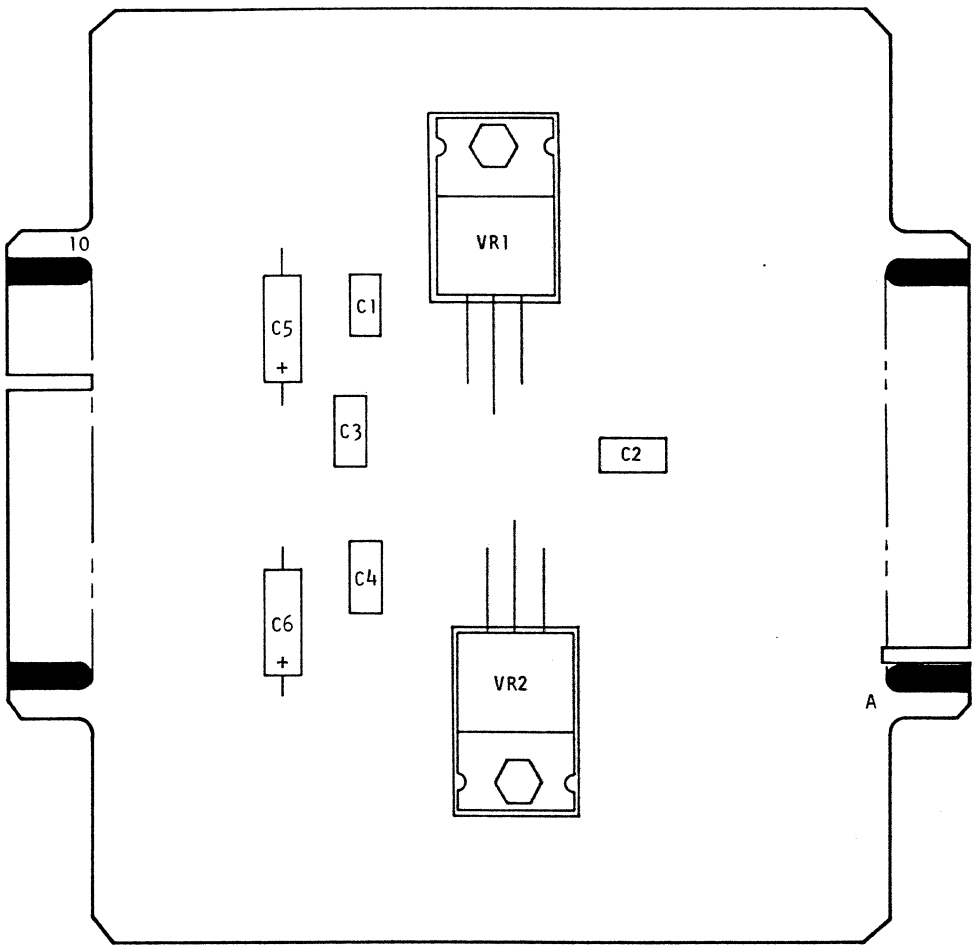
E-536450-X1 (REF)

Figure 6-10. Amplifier Case Assembly



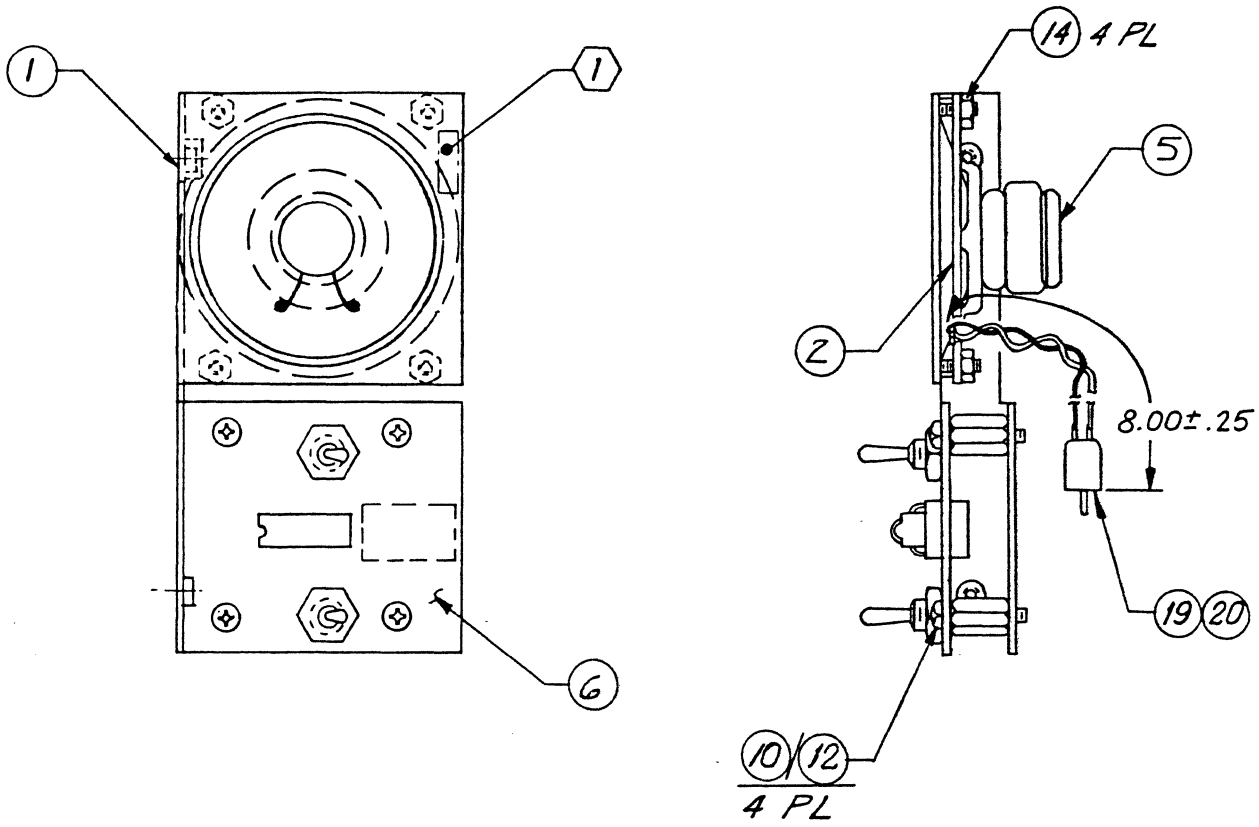
E-539920-A (REF)

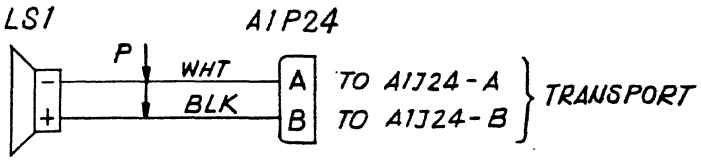
Figure 6-11. Mother Board Assembly, Amplifier Case



D-540996-B (REF)

Figure 6-12. Preamplifier Voltage Regulator





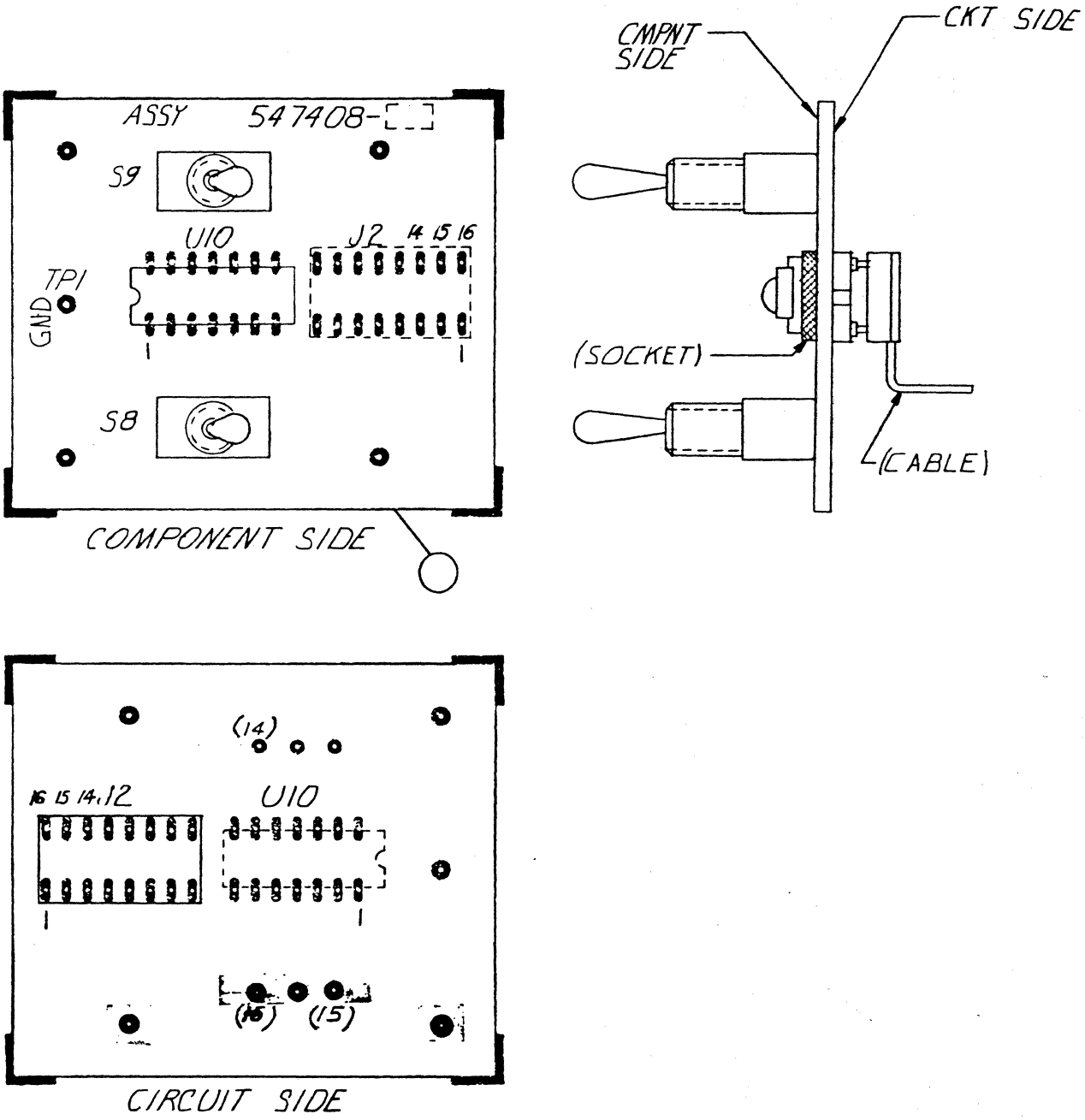
WIRING DIAGRAM
LOUDSPEAKER

(1) MARK PART NUMBER AND LATEST REVISION LETTER PER MIL-STD-130 APPROXIMATE WHERE SHOWN.

NOTES: UNLESS OTHERWISE SPECIFIED

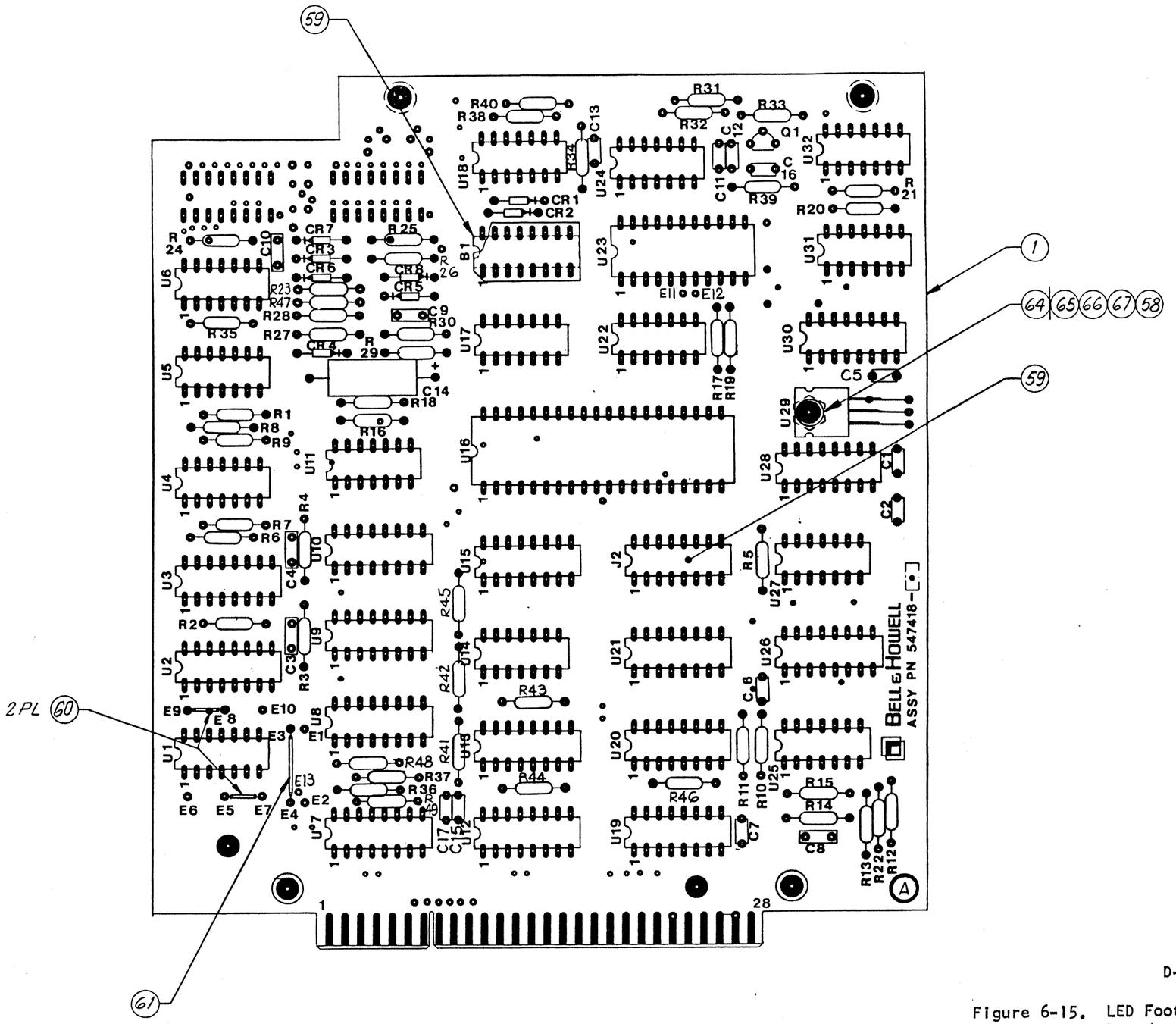
D-547432-A (REF)

Figure 6-13. Loudspeaker and Display Assembly Bracket



D-547408-B (REF)

Figure 6-14. Counter/Display and Shuttle Control Assembly



D-547418-A (REF)

Figure 6-15. LED Footage Counter Control Board

SECTION VII

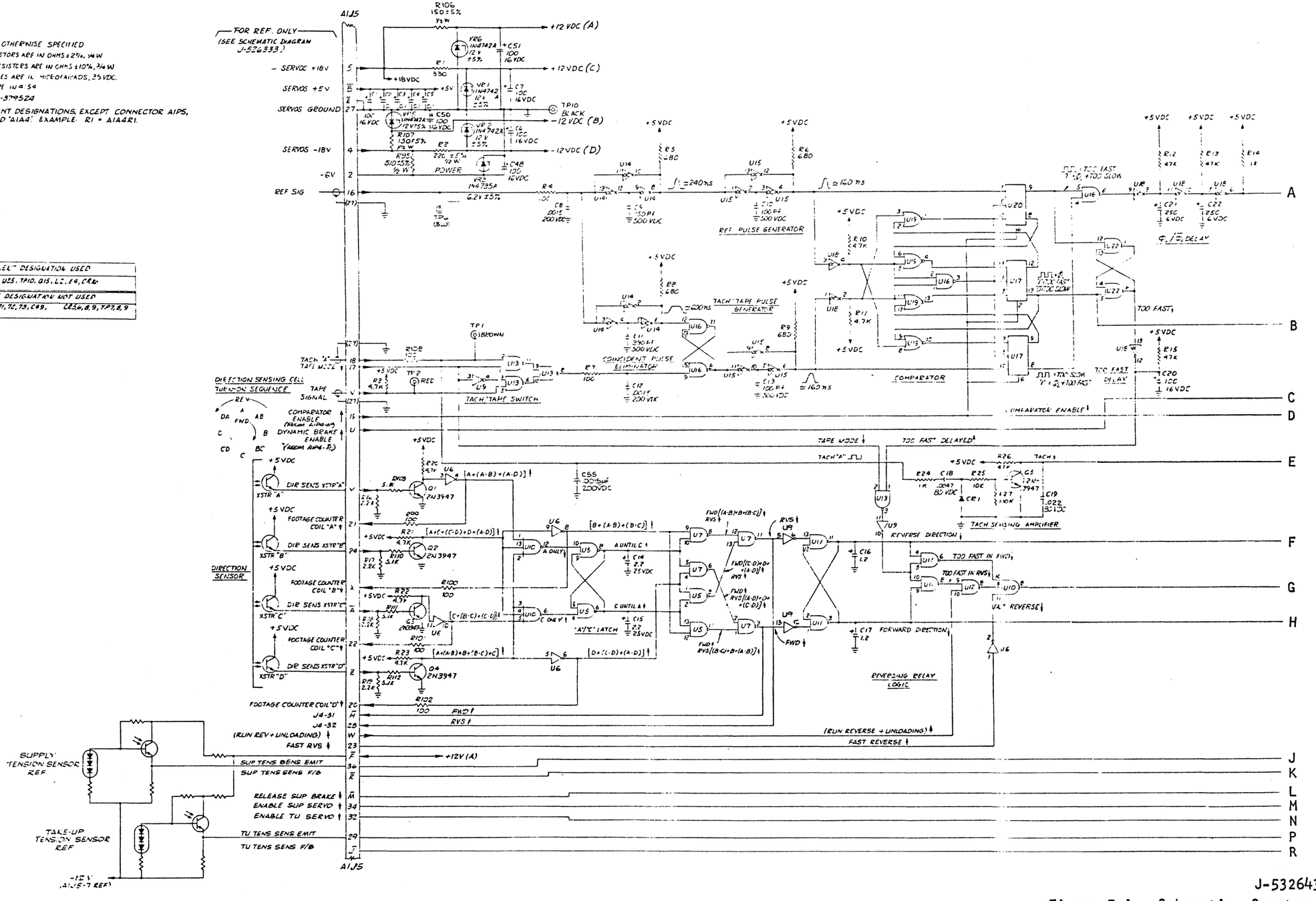
SCHEMATICS

7-1. GENERAL.

7-2. This section contains the schematic diagrams (figures 7-1 through 7-10) for the 12-401D Tape Transport.

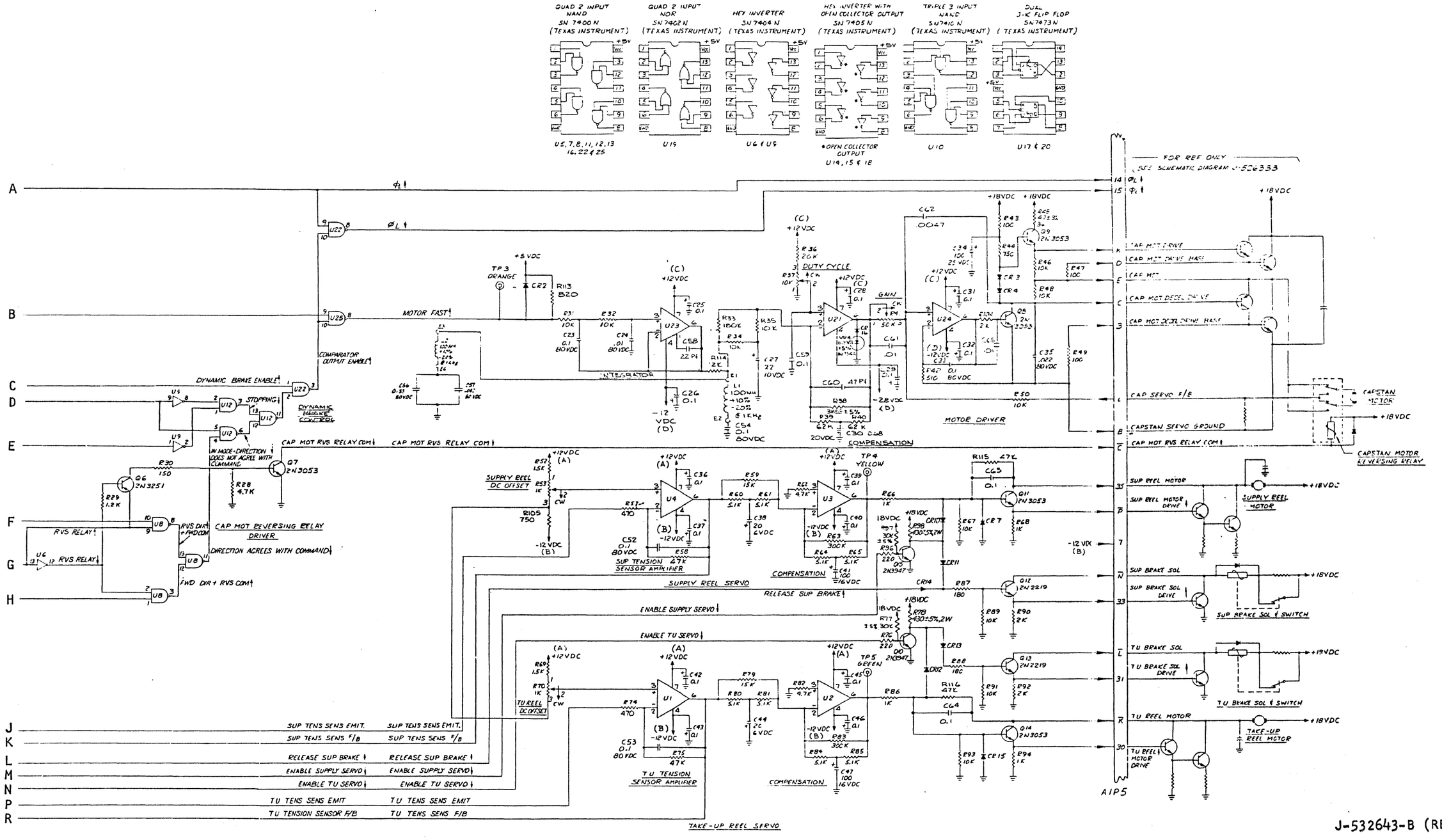
NOTES: UNLESS OTHERWISE SPECIFIED
1 ALL FIXED RESISTORS ARE IN OHMS ±2%, ¼W
2 ALL VARIABLE RESISTORS ARE IN OHMS ±10%, ¾W
3 ALL CAPACITANCES ARE IN MICROFARADS, 35VDC.
4 ALL DIODES ARE IN4154
5 SIMILAR TO J-579524
6 ALL COMPONENT DESIGNATIONS, EXCEPT CONNECTOR AIPS, ARE PREFIXED "A1A4". EXAMPLE: R1 = A1A4R1.

LAST COMPOSITE DESIGNATION USED
R116, C67, VR4, U25, TP10, Q15, L2, E4, CR2
COMPONENT DESIGNATION NOT USED
R51, 54, 55, 56, 71, 72, 73, C49, L25, 6, 8, 9, TP7, 8, 9



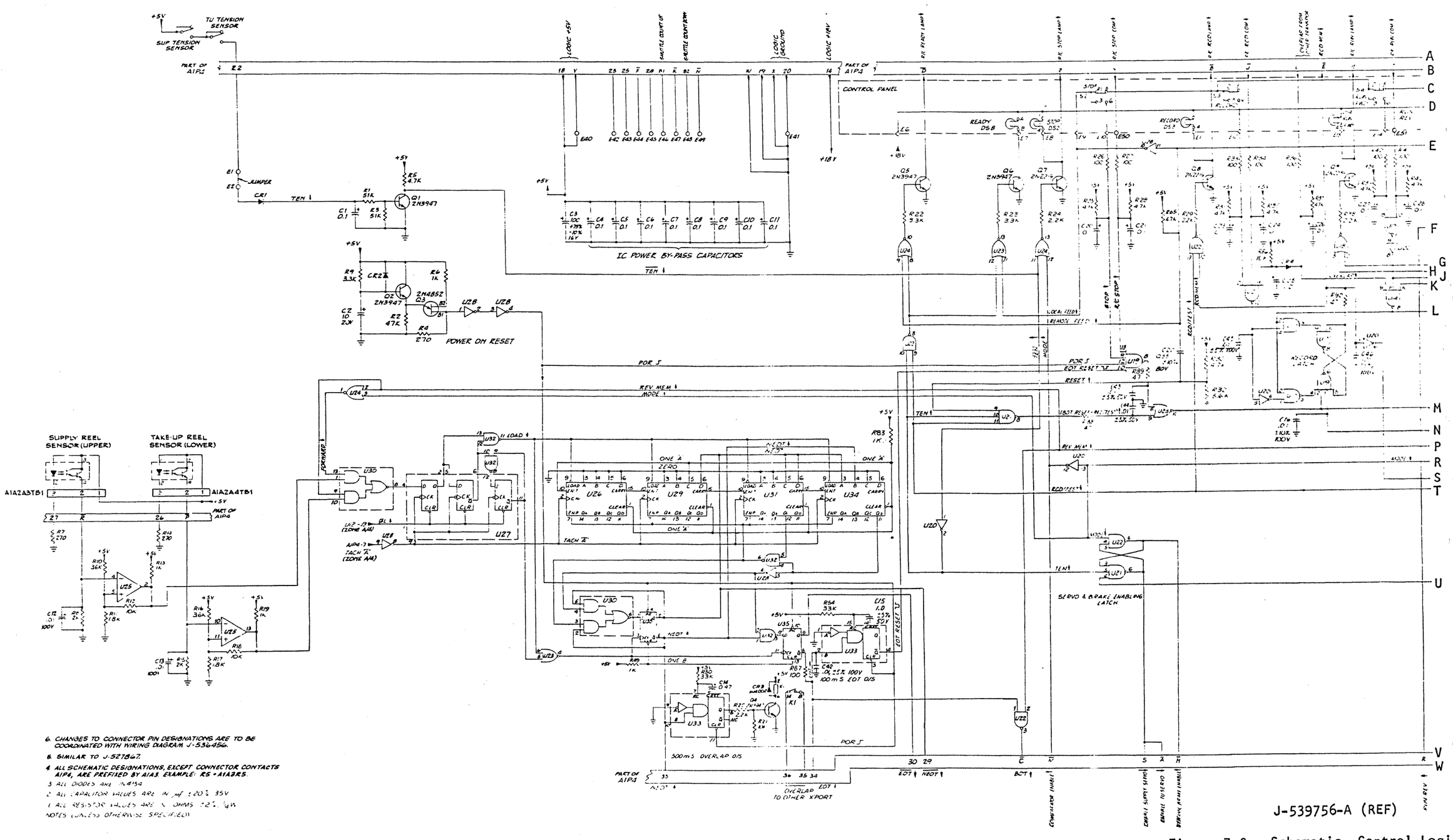
J-532643-B (REF)

Figure 7-1. Schematic, Capstan and Reel Servos (Sheet 1 of 2)



J-532643-B (REF)

Figure 7-1. Schematic, Capstan and Reel Servos (Sheet 2 of 2)

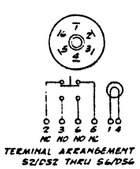


6. CHANGES TO CONNECTOR PIN DESIGNATIONS ARE TO BE COORDINATED WITH WIRING DIAGRAM J-539456.
5. SIMILAR TO J-527867.
4. ALL SCHEMATIC DESIGNATIONS, EXCEPT CONNECTOR CONTACTS AIP4, ARE PREFIXED BY A1A3. EXAMPLE: R5 = A1A3R5.
3. ALL DIODES ARE 1N4154
2. ALL CAPACITOR VALUES ARE IN μf ±20% 35V
1. ALL RESISTOR VALUES ARE IN OHMS ±2% 1/4W.

NOTES (UNLESS OTHERWISE SPECIFIED)

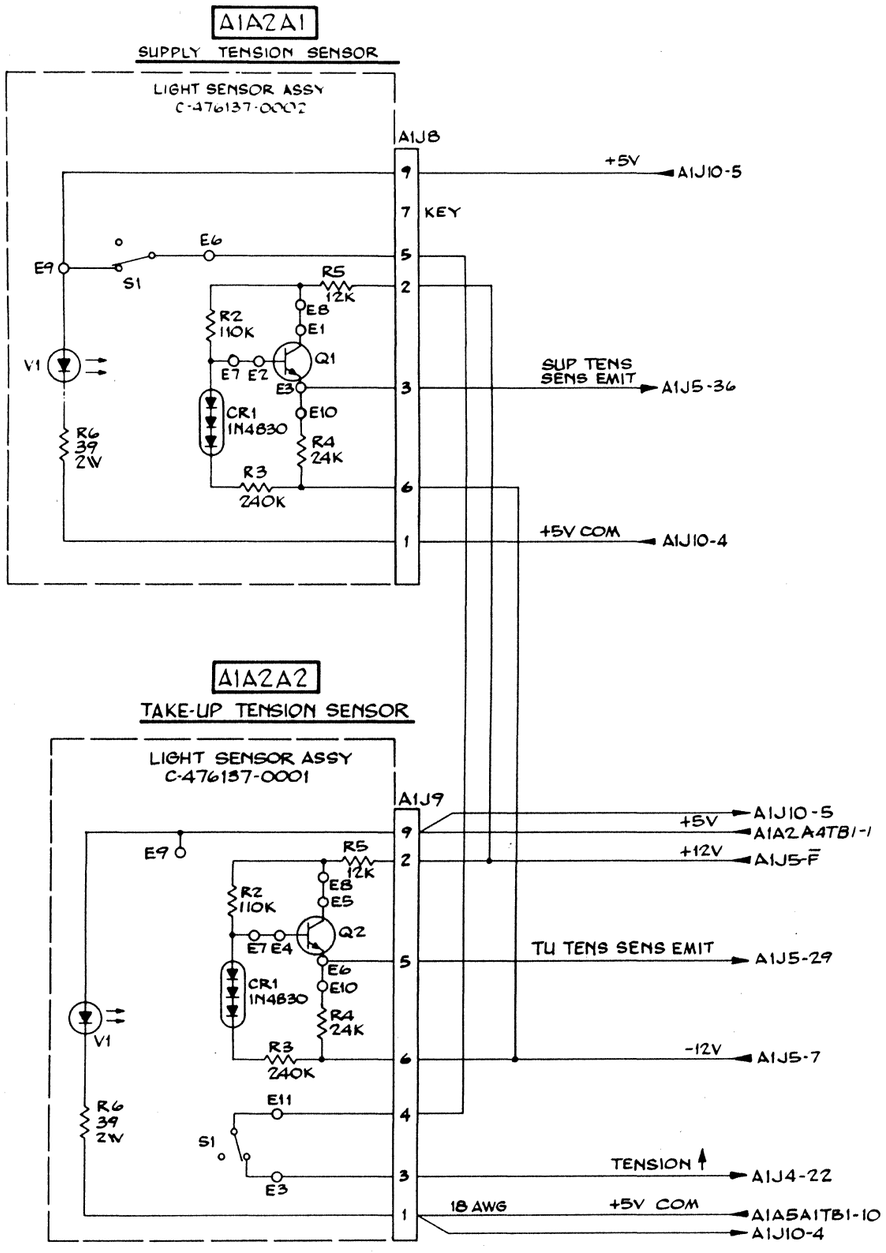
Figure 7-2. Schematic, Control Logic (Sheet 1 of 2)

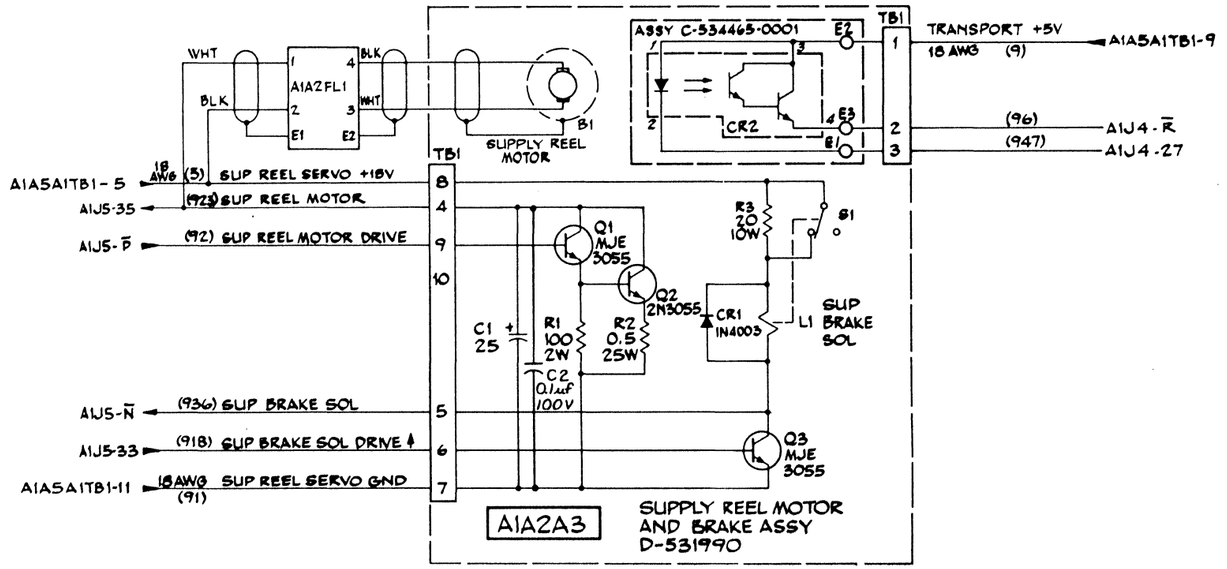
IC TABULATION					
IC TYPE NO	SCHEMATIC DESIGNATION	GND PIN	Vcc PIN	PIN NOS OF SECTIONS NOT USED	REMARKS
7400	U10	7	14	(8,9,10)	
	U12, U16, U17, U32				
	U22				
74H00	U1	7			
7402	U3, U9	7	14	(4,5,6)	
	U18, U24				
	U6, U23			(1,2,3)	
7404	U16, U20	7	14		
	U11, U28			(12,13)	
7410	U13, U14, U21	7	14		
7420	U8, U19	7	14		
7451	U30	7	14		
74H73	U4	11	4		
7474	U35	7	14		
7490	U7	10	5		
7427	U5	7	14		
74123	U33	8	16		
74161	U26, U29, U31, U34	8	16		
74175	U27	8	16	(13,14,15)	
LM339	U25	12	3	(4,6,7)(8,9,14)	
74393	U2	7	14		

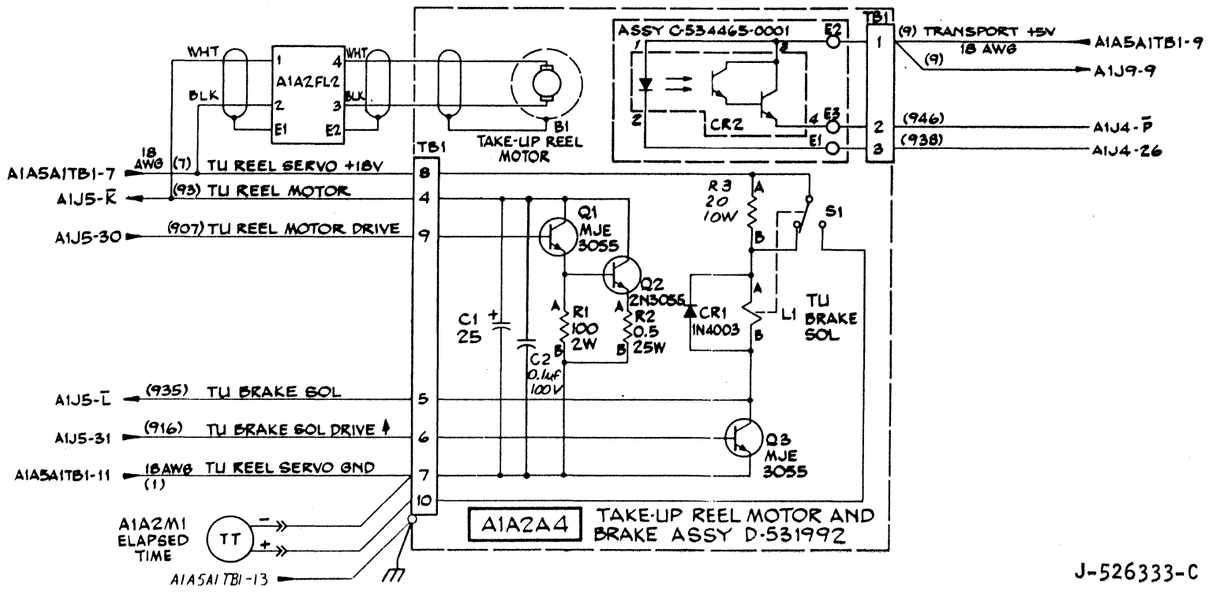


J-539756-A (REF)

Figure 7-2. Schematic, Control Logic (Sheet 2 of 2).

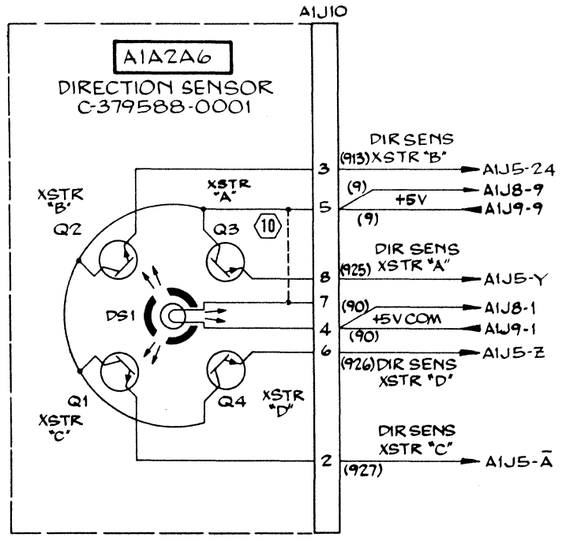


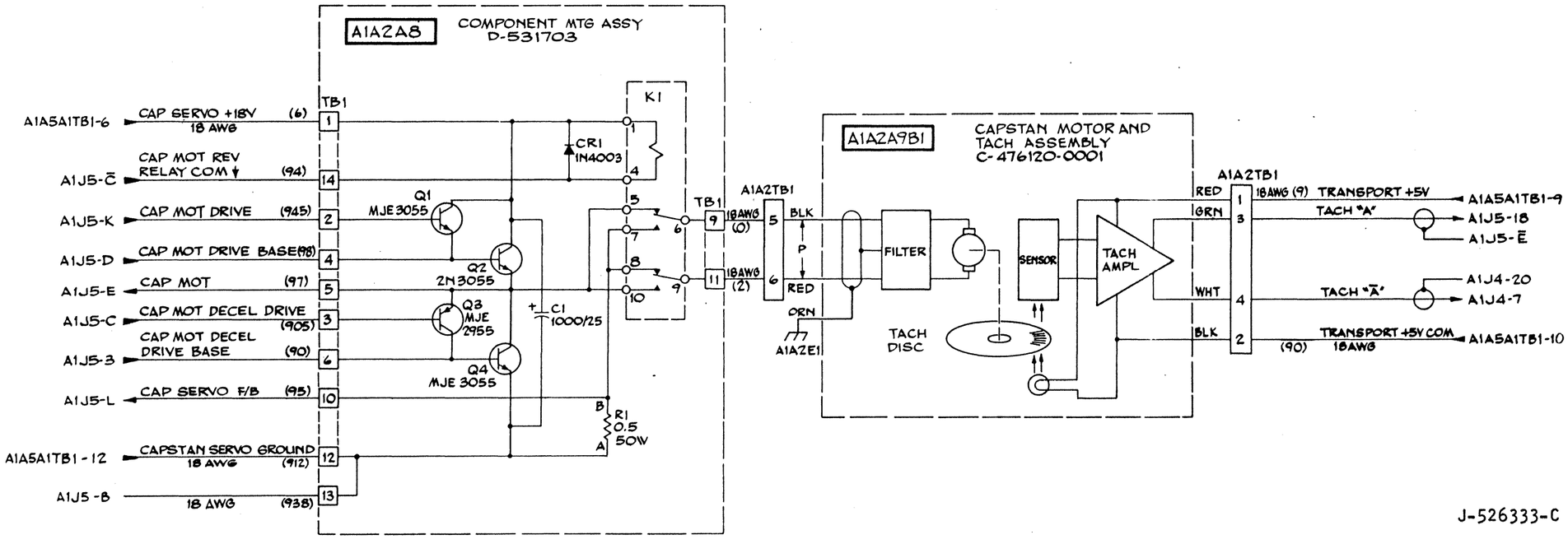




J-526333-C (REF)

Figure 7-3. Schematic, Transport Assembly (Sheet 1 of 2)





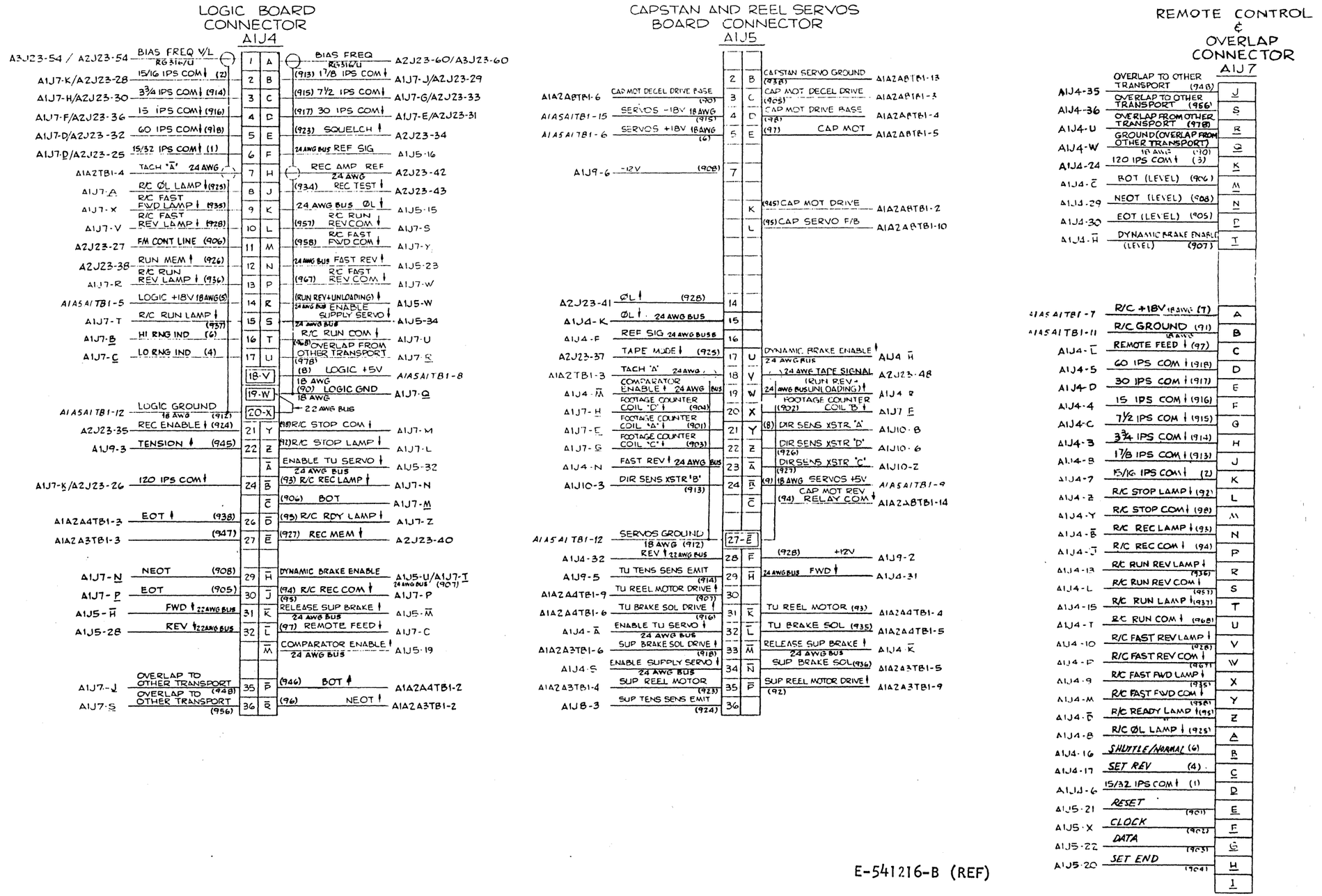
(10) JUMPER A1J10-5 FOR 379588-0002 ASSY.

9. ALL WIRES ARE 22 AWG.
8. SIMILAR TO J-520947.
7. FOR INTERCONNECTION WIRING SEE WIRING DIAGRAM E-526202.
6. ALL TRANSISTORS ARE NPN PHOTOSENSITIVE FPT100 (FAIRCHILD).
5. ALL SCHEMATIC DESIGNATIONS FOR COMPONENTS LOCATED WITHIN SEPARATE ASSEMBLIES WILL BE PREFIXED BY THE ASSEMBLY DESIGNATION. EXAMPLE: Q1 IN ASSEMBLY A1A2A1 WILL BE A1A2A1Q1.
4. ANY CHANGES TO LEGEND OR CONTACT DESIGNATIONS MUST BE COORDINATED WITH SCHEMATICS E-526202, J-527867 AND J-532643.
3. "▲" INDICATES LOGIC "1" (+5 V), "▼" INDICATES LOGIC "0" (GROUND).
2. ALL CAPACITOR VALUES ARE IN µF $^{+75}_{-10}$%, 50 V.
1. ALL RESISTOR VALUES ARE IN OHMS ±5%, 1/4 W.

NOTES: UNLESS OTHERWISE SPECIFIED.

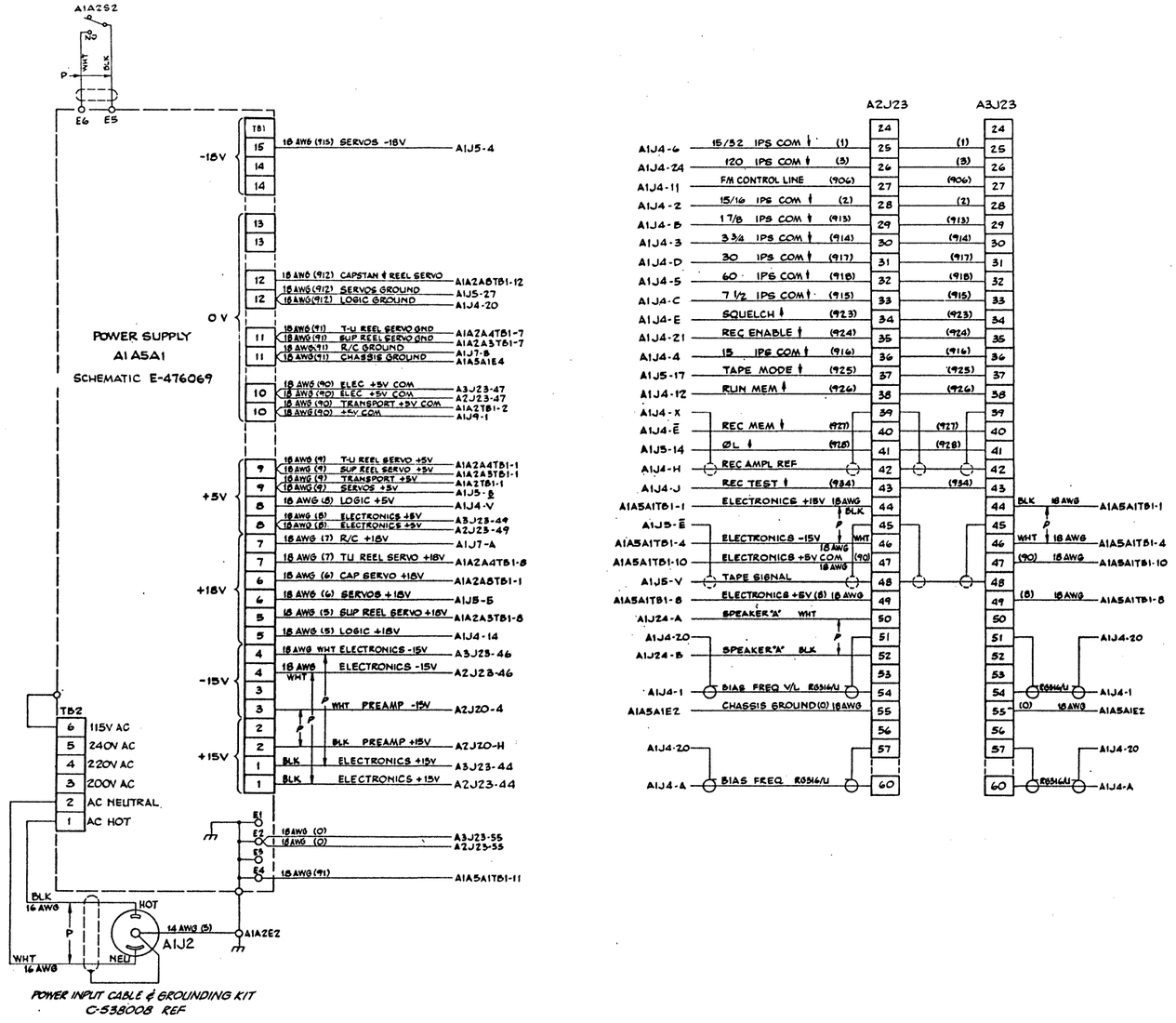
J-526333-C (REF)

Figure 7-3. Schematic, Transport Assembly (Sheet 2 of 2)



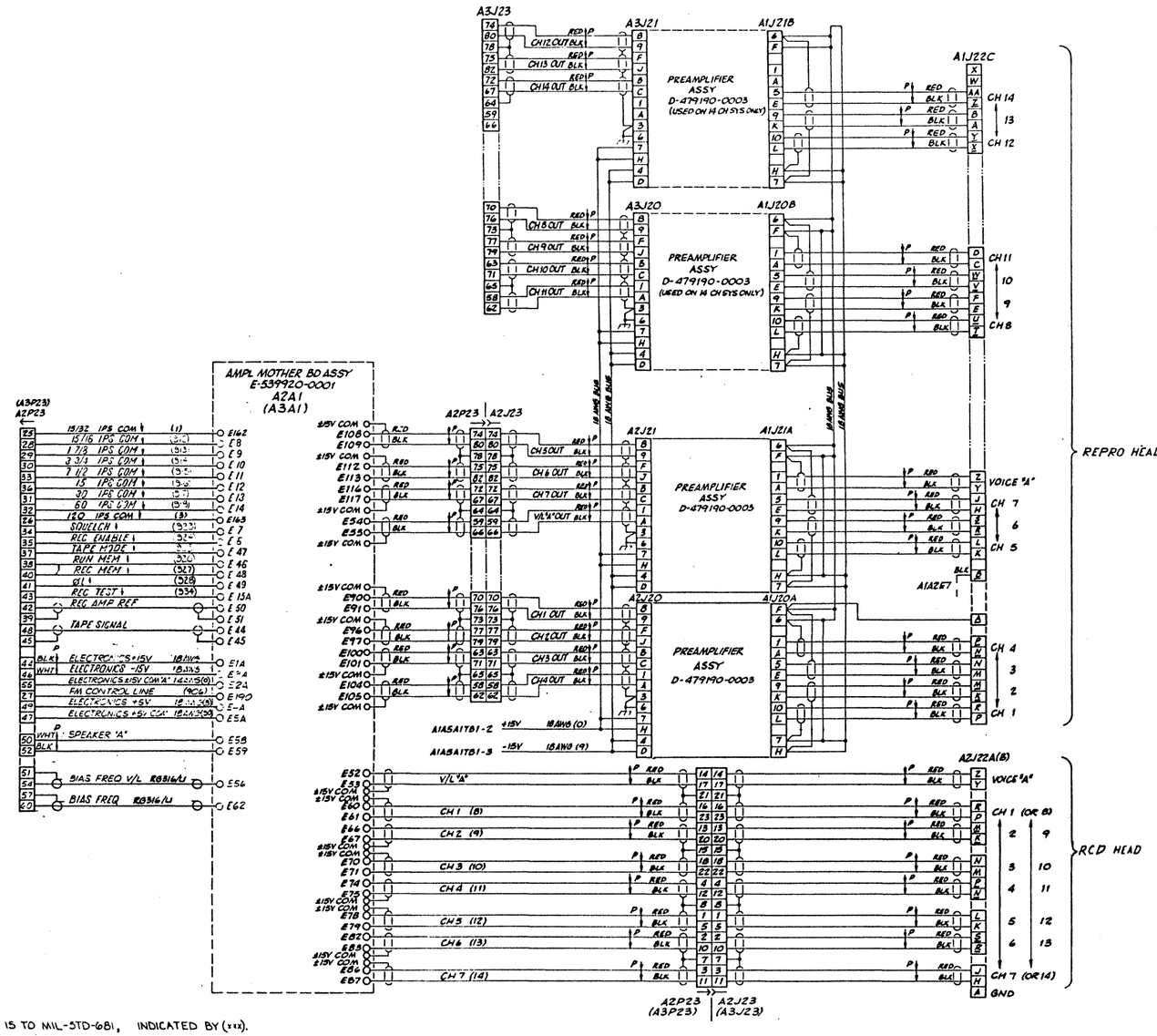
E-541216-B (REF)

Figure 7-4. Schematic, Transport Connectors



C-536456-X2 (REF)

Figure 7-5. Schematic, Transport Terminal Cards

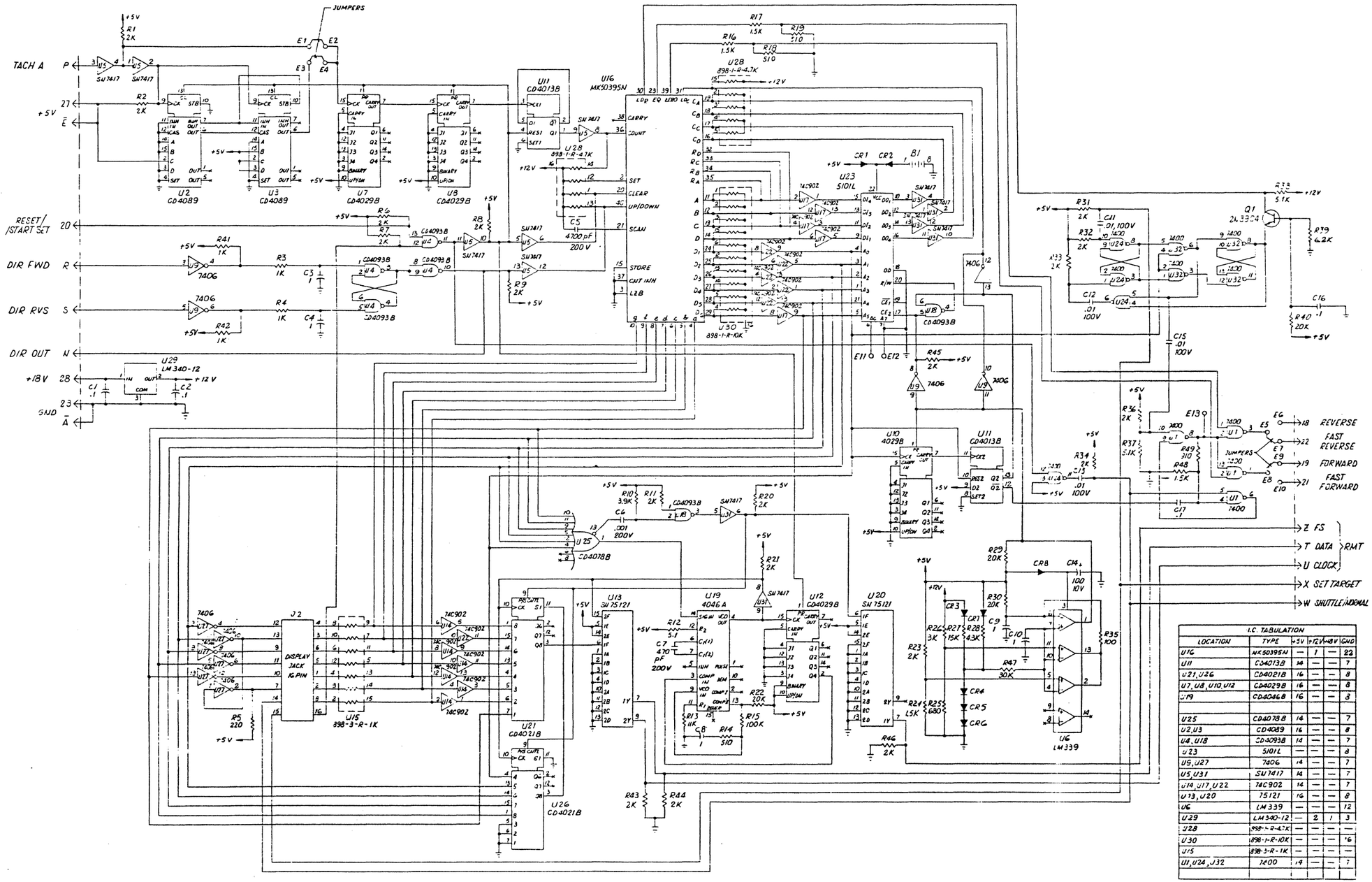


6. SIMILAR . J E-526202.
5. COLOR CODING OF WIRES IS TO MIL-STD-681, INDICATED BY (xxx).
4. ALL SHIELDED CABLES HAVE 24 AWG CONDUCTORS
3. ALL WIRES ARE 22 AWG.
2. CONTACT DESIGNATIONS INDICATED THUS, "A", ARE LOWER CASE, "a".
1. FOR 1" TAPE/14 CH SYSTEM A SECOND AMPL CASE ASSY, 12-405A, IS USED DESIGNATED "A3A1". WIRING IS IDENTICAL TO THE 7CH SYSTEM.

(OTHERWISE SPECIFIED)

C-536456-X2 (REF)

Figure 7-6. Schematic, 12-405A Amplifier Case



I.C. TABULATION

LOCATION	TYPE	+5V	+12V	-18V	GND
U16	MK50395N	—	1	—	22
U11	CD4013B	14	—	—	7
U21, U26	CD4021B	16	—	—	8
U7, U8, U10, U12	CD4029B	16	—	—	8
U19	CD4046B	16	—	—	8
U25	CD4078B	14	—	—	7
U2, U3	CD4089	16	—	—	8
U4, U18	CD4093B	14	—	—	7
U23	5101L	—	—	—	8
U9, U27	7406	14	—	—	7
U5, U31	SN7417	14	—	—	7
U14, U17, U22	74C902	14	—	—	7
U13, U20	75121	16	—	—	8
U6	LM339	—	—	—	12
U29	LM340-12	—	2	1	3
U28	898-1-R-4.7K	—	—	—	—
U30	898-1-R-10K	—	—	—	16
U15	898-3-R-1K	—	—	—	—
U1, U24, U32	7400	14	—	—	7

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIODES ARE IN4148.
2. RESISTOR VALUES ARE IN OHMS ±2%, 1/4 W.
3. CAPACITOR VALUES ARE IN µF ± 20%, 50 V.
4. —× DENOTES NO CONNECTION.

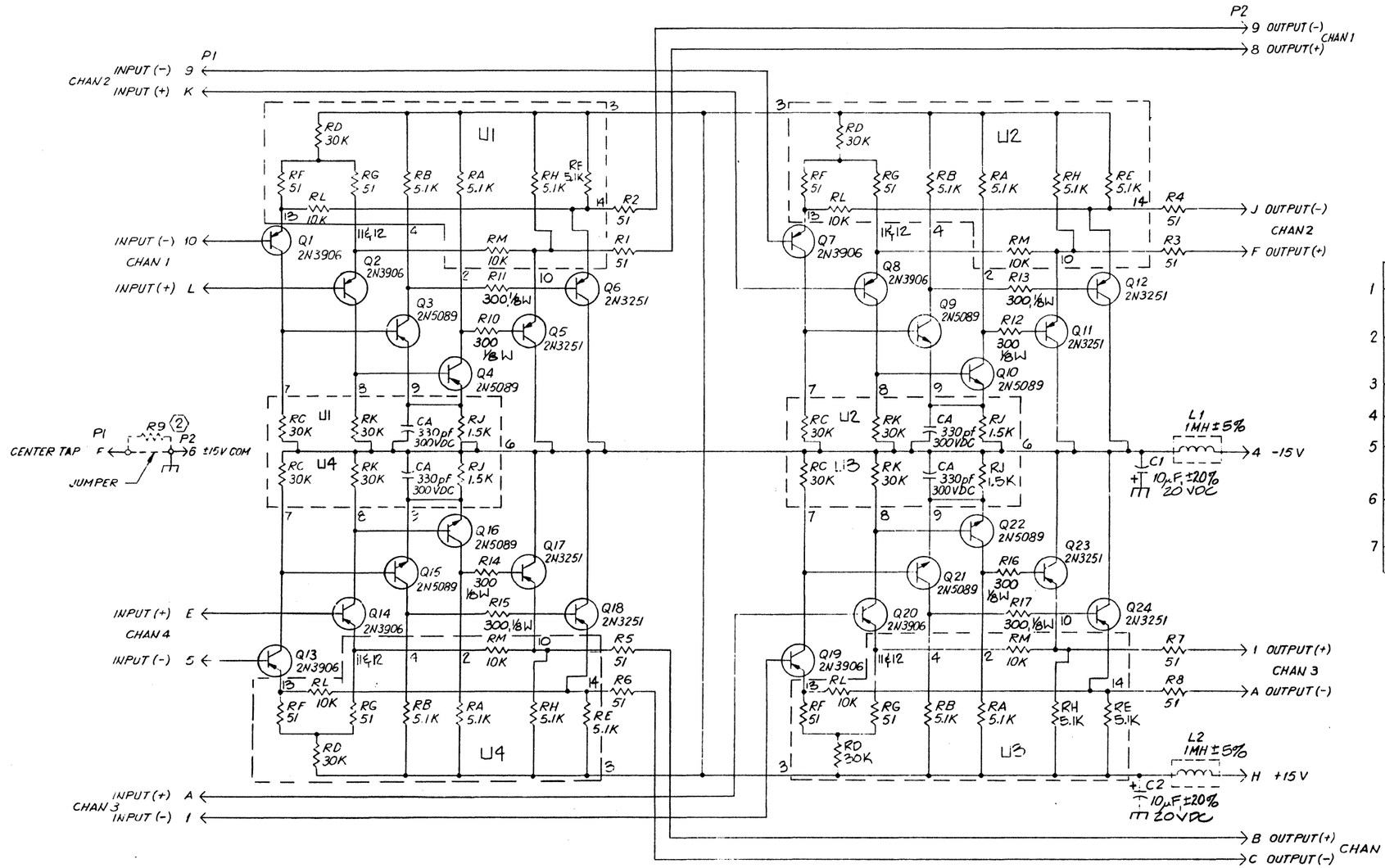
NOT USED SECTIONS

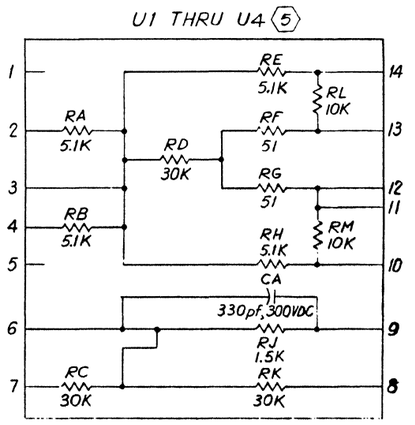
U9 7406

U18 4093B

E-547417-A (REF)

Figure 7-7. Schematic, LED Footage Counter and Shuttle Control





LAST COMPONENT DESIGNATION USED
C2, L2, Q24, R17, U4

(5) CAPACITOR CA AND RESISTORS RA THRU RM FORM 14 PIN DIP NETWORK U1, U2, U3, U4. U1 IS FOR CH1, U2 IS FOR CH2, ETC. RESISTOR "RA" THRU "RM" ARE ±2%, 1/8W.

4. ALL DISCRETE RESISTOR VALUES ARE IN OHMS ±2%, 1/4 W.

3

(2) R9 IS NOT PART OF THE STANDARD BOARD. SHOWN FOR REF. ONLY. IT IS SHOWN TO INDICATE FULL CAPABILITIES.

1. SIMILAR TO 479191

NOTES: UNLESS OTHERWISE SPECIFIED.

D-540755-X1 (REF)

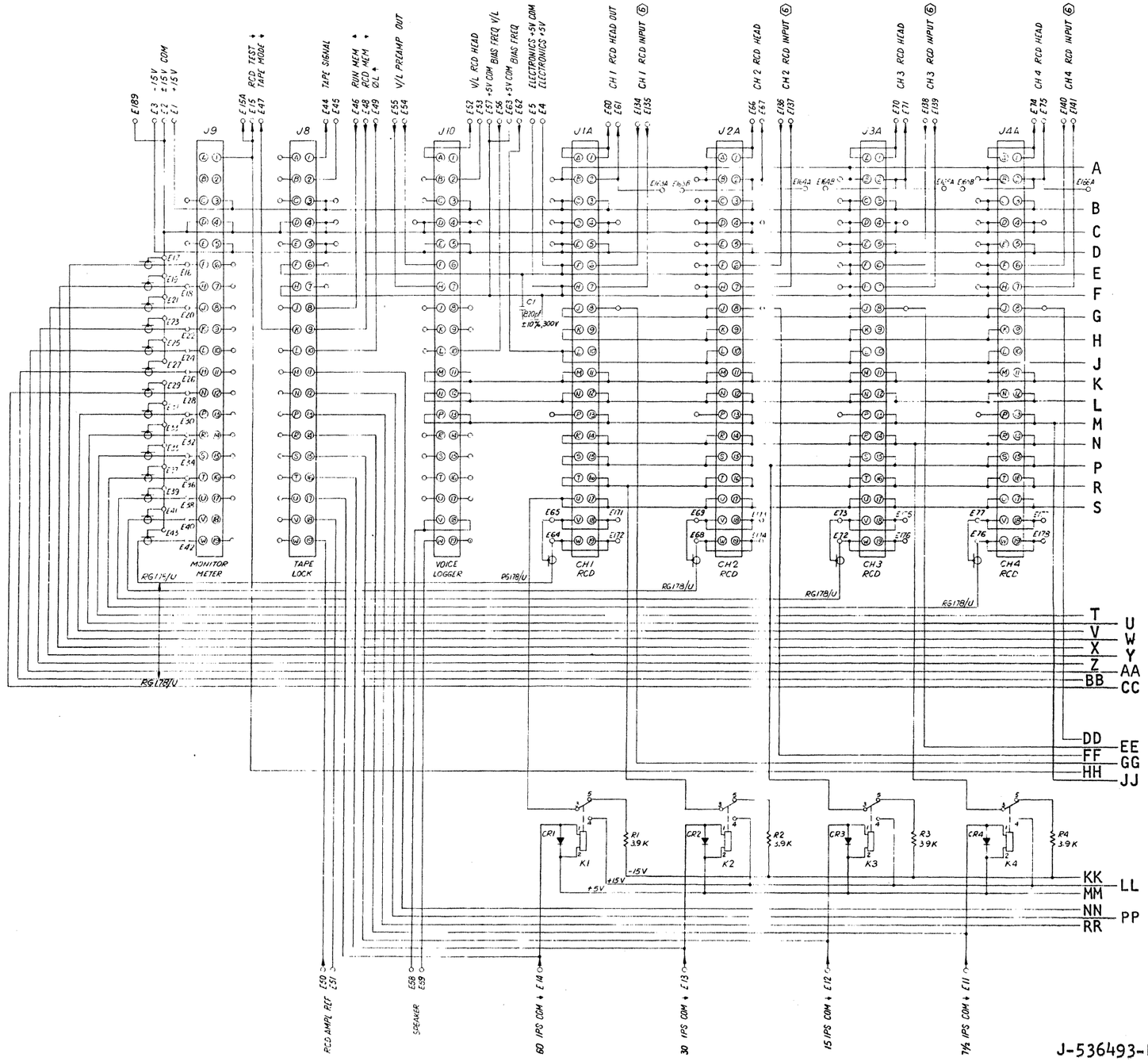
Figure 7-8. Schematic, Preamplifier

TABULATION BLOCK			
SCHEMATIC	NEXT ASSY		APPLICATION
536493-0001	536492-0001	DELETE RELAYS K8,K10,K11,K12, K14, & DIODE CR8. ADD JUMPERS FROM E163A TO E169B, FROM E170A TO E170B, FROM E185A TO E185B, FROM E186A TO E186B, FROM E187A TO E187B & FROM E188A TO E188B.	USED FOR SINGLE ENDED REPRODUCE OUTPUT. SPECIAL APPLICATION ONLY.
536493-0002	536492-0002	DELETE RELAYS K8,K10,K11,K12, K14, DIODE CR8 & CAPACITOR C4.	USED ON STANDARD CPR4010B & CPR4040. W/O FM TEST CIRCUIT.
536493-0003	536492-0003	DELETE CAPACITOR C4.	USED ON STANDARD 4020 WITH FM TEST CIRCUIT.

LAST COMPONENT DESIGNATION USED
C11, CR11, E190, J10, K14, Q1, R9

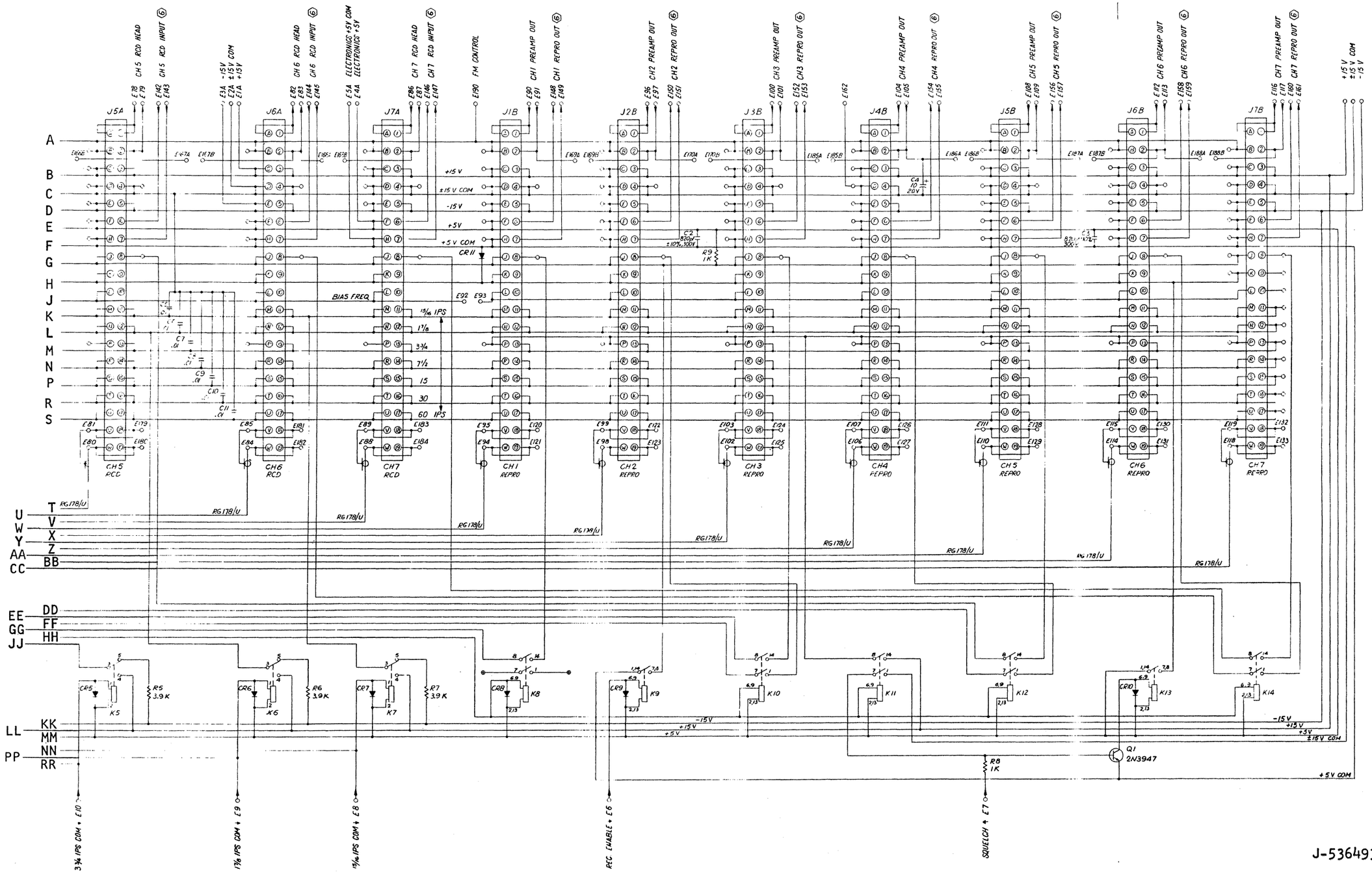
8. SYMBOL "⊕" INDICATES UNIDENTIFIED SPARE PADS ON CIRCUIT CARD.
7. INDICATED INPUTS ARE USED FOR RACKMOUNT CONVERSION. THEY ARE NOT THE STD. INPUTS.
6. ASSY'S A2A1 AND A3A1 ARE IDENTICAL. ALL COMPONENT DESIGNATIONS ARE PREFIXED WITH "A2A1" IF USED FOR AMPL CASE FOR CHANNELS 1 THRU 7 OR "A3A1" IF USED FOR AMPL CASE FOR CHANNELS 8 THRU 14. EXAMPLE: RESISTOR R1 = "A2A1R1" IF USED FOR CHAN'S 1 THRU 7 OR R1 = "A3A1R1" IF USED FOR CHAN'S 8 THRU 14.
5. SYMBOL ↑ INDICATES HIGH LEVEL LOGIC (+5 V NOM).
4. SYMBOL ↓ INDICATES LOW LEVEL LOGIC (0 V NOM).
3. ALL DIODES ARE 1N4003.
2. ALL RESISTORS ARE IN OHMS ± 2%, 1/4 WATT.
1. ALL CAPACITORS ARE IN μF ± 20%, 100V.

NOTES: UNLESS OTHERWISE SPECIFIED



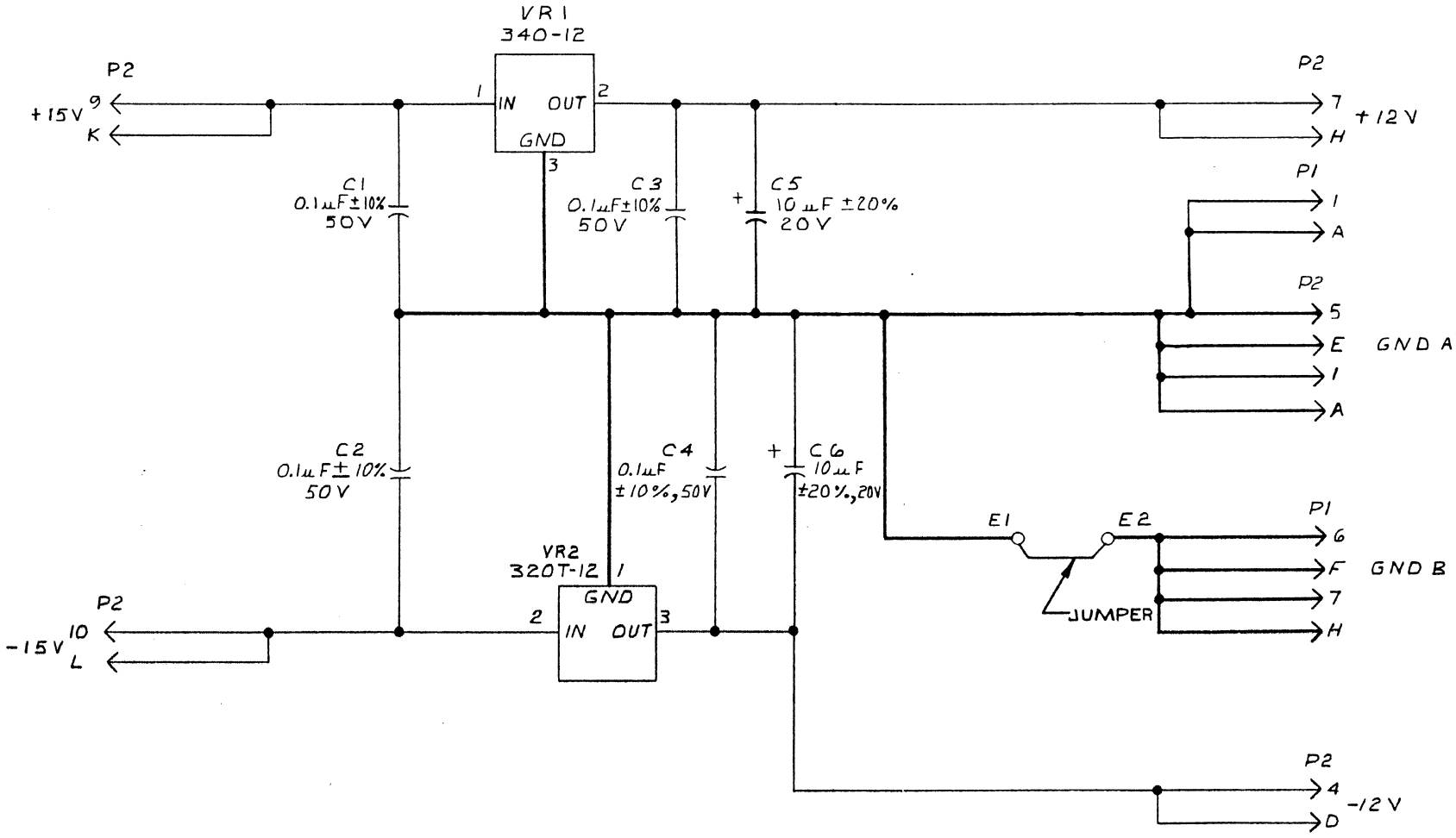
J-536493-B (REF)

Figure 7-9. Schematic, Amplifier Case Mother Board (Sheet 1 of 2)



J-536493-B (REF)

Figure 7-9. Schematic, Amplifier Case Mother Board (Sheet 2 of 2)



D-540997-A (REF)

Figure 7-10. Schematic, Preamplifier Voltage Regulator